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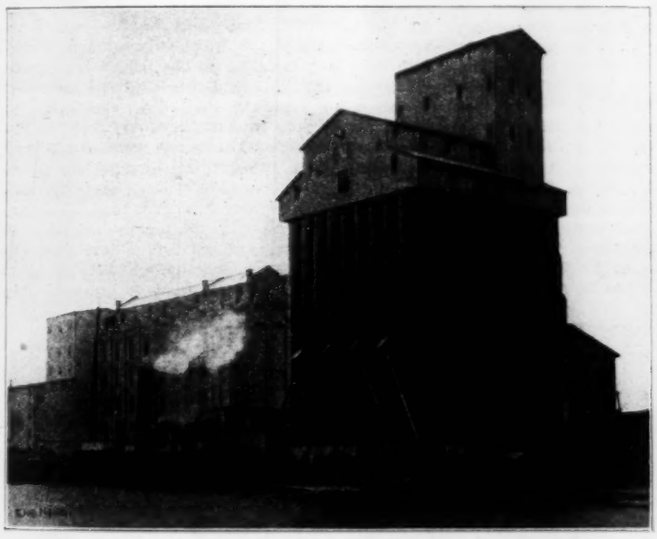
FAILURE OF A STEEL ELEVATOR AT FORT WILLIAM, ONT.

By J. A. M.

A great steel-tank grain elevator, at Fort William, Ont., belonging to the Ogilvie Flour Mills Co., failed on the night of May 26, by sliding forward into the Kaministiquia River, beside which it was erected. The failure occurred without warning, but the only man who was in the building at the time escaped without injury. The elevator structure was built in 1904 by the McDonald Engineering Co., of Chicago, at an estimated cost of $300,000. Its capacity was 500,000 bushels, and about 380,000 bushels were in the tank when the failure occurred, of which about 150,000 bushels were discharged into the river.



VIEW BEFORE FAILURE.

VIEW AFTER FAILURE.

STEEL TANK ELEVATOR OF THE OGILVIE FLOUR MILLS CO. AT FORT WILLIAM, ONT.

The machinery was not running at the time of the failure.

The structure covered a ground area of 80 by 94 ft. and the tanks were 85 ft. deep. It was carried on piles spaced 3 ft. c. to c. and driven 35 ft. to bedrock. These were capped with a reinforced concrete footing course. The fallen structure has moved about 45 ft. from its former position and the tanks are now resting on the bottom in 26 ft. of water.

TRANSMISSION AND DISTRIBUTION SYSTEM, LONG ISLAND R. R.

In our issue of Nov. 2, 1905, we outlined the proposed electric traction lines of the Long Island R. R. and gave a general description of the power plant and sub-stations and of the distribution system and train equipment provided for their operation. A more detailed description of the power station construction was given in our issue of May 31. The present article supplements these previous articles with a description in detail of the novel and the more important structural features, of the transmission and distribution system.

GENERAL DESCRIPTION.

The first duty of the Long Island City power station of the Pennsylvania Railroad Company has been to supply power for operating the suburban lines of the Long Island R. R. This supply and distribution of power is by means of a high tension three-phase transmission line which carries current at 11,000 volts to six rotary converter substations. Direct current feeders go out from these substations to the conductor rail, feeding it at numerous points on each division. The high tension transmission line is mainly overhead (26.19 miles) but certain portions within the densely populated sections of Brooklyn and Queens Boroughs are underground conduit lines (9.09 miles). Both the overhead and the underground sections are of unusually substantial design and exhibit a number of points of novelty. The trunk portion of the overhead transmission line is carried on steel columns which were chosen not so much for their durability as because the weight of the transmission lines in these portions considerably exceeded what was thought allowable for wooden poles. This main portion of the line comprises eight three-phase circuits, each consisting of three 250,000 c. m. cables and eight low tension feeder cables each 500,000 c. m. in cross-section, the latter being carried below the high tension lines. It was required to carry these circuits at such a height that the lowest wire would be not less than 25 ft. above the ground, and this in turn required the poles to be from 39 to 54 ft. long above ground. It is evident that wooden poles are virtually prohibited by these requirements. Where the transmission line branches from the end of the trunk, however, no single line will contain more than two three-phase circuits and four low tension feeders, and for this service wooden poles were thought to be adequate. This includes the line along the five-mile trestle across Jamaica Bay, where creosoted yellow pine poles, 60 to 80 ft. long, sunk by water-jet into the bay and braced to the trestle, are used. Except on this trestle, all wooden poles are of chestnut. The total of the overhead transmission line includes 377 steel poles, 490 chestnut poles and 264 creosoted yellow pine poles.

The six substations above mentioned are fixed structures supplying power continuously. At two points of the system, large race tracks, which draw a very heavy attendance during a short summer season, place very large temporary loads on the system. To supply the power for this without installing the large additional equipment of machinery required to furnish it from a fixed substation, two portable substations have been provided and suitable sheds for them have been built at the two race tracks. The sheds are equipped with fixed leads from the transmission line and feeders to the third rail of the track. To supply power, the portable substation car is run into the shed connected by jumpers to the high tension and low tension leads respectively, and put into operation in the same way as a fixed substation. So much for the general arrangement; the principal structural details will now be considered.

UNDERGROUND LINE CONSTRUCTION.

As previously stated, something over nine miles of the transmission line is underground line. The

VIEW OF TRACK, SHOWING ARRANGEMENT OF THIRD RAIL AT SWITCHES AND CROSS-OVERS.

conduit construction involves little that is out of the ordinary. For the greater portion of the line single vitrified clay ducts 18 ins. long, with $3^{11}/_{16}$-in. square holes and $^{3}/_{4}$-in. walls, are laid to break joints in cement mortar and arranged three wide and six high, the whole being embedded in concrete. For the remainder of the line four-way ducts 36 ins. long are used. The lines of ducts are provided with the usual manholes located generally 400 ft. apart. Practically the only novel feature of the work is the provision for drainage; considerable lengths of the conduit were located below ground water level, and in these portions the manholes are connected by a line of 8-in. sewer pipe laid beneath the ducts and entering the manholes about 18 ins. from the bottom, thus forming a catch basin to prevent silt or other foreign matter from getting into and clogging the pipe. This conduit line is so pitched as to bring all the drainage into three sumps, one located at the power station, one about one-half mile from it, and the third near the Dutch Kills St. end of the conduit line. These sumps are kept pumped out by electrically driven submerged centrifugal pumps, automatically controlled and discharging into the city sewer system.

In the conduits there are in all about 25 miles of high tension underground cables and in addition 0.418 mile of armored submarine cable under Jamaica Bay. The submarine cable only calls for particular mention, because of the method of laying it. The cables were laid across the channel and allowed to settle to the bottom. A diver then arranged them so that they were properly separated, and they were sunk into the mud by means of a water-jet, supplied by pumps at 100 lbs. pressure. By means of this jet, the diver was able to scour out a trench wide enough to contain the cables, 4 ft. below the bottom of the channel. This method of installation was preferred to dredging because of the difficulty which would have been encountered in attempting to dredge the trench through the fender piles on either side, and because of the rapid current through the channels, which would fill with sand a trench so dredged immediately after excavation, unless the cables should be laid during the dredging process, which was obviously impracticable.

OVERHEAD LINE CONSTRUCTION.

The general character of the overhead line construction has been mentioned in the preceding paragraphs. The points of particular interest are the steel pole construction, and the insulator pins and insulators.

STEEL POLES.—The steel poles are built of four corner angles connected together by angles and plates forming a lattice type of construction. They are tapered uniformly to the top on two sides and to within about 7½ ft. of the top on the other two sides, the taper being ⅜-in. per foot. This taper is uniform to the bottom of the pole and is the same for all lengths of poles. The tops are in every case 6 by 11 ins. At the bottom the corner angles are tied to a base composed of plates and channels through the corners of which the four anchor bolts pass. This forms a sort of box construction around the base of the pole and greatly increases its stiffness and stability. This type of construction enables a foundation to be built and the anchor bolts set at any convenient time independent of the delivery of the poles. This permits the most desirable degree of flexibility in the organization of the pole setting force, thus dividing it into practically two separate gangs, neither of which is hampered by the movements of the other.

The standard poles are made in four lengths, increasing by 5 ft., from 39 ft. to 54 ft. in length, the 39-ft. pole being the standard. Other lengths being only used where nec[illegible] on account of the above mentioned uni[illegible] taper, the sizes of the bases vary from 3½ [illegible] ft. to 4½ by 5 ft., depending on the height [illegible] pole. The foundations are therefore propo[illegible] ed accordingly. From a detailed survey [illegible] the line the length and the location of every p[illegible] was determined upon before construction [illegible] and every foundation built to fit the size [illegible] pole assigned to that particular location.

The poles are designed to withsta[illegible] a wind pressure at right angles to the line [illegible] sponding to a wind velocity of 100 mile[illegible] hour. This was calculated from data obtai[illegible] in the Berlin Zossen high speed railway t[illegible] which showed the pressure on a flat surfac[illegible] to a wind velocity of 100 miles per hour t[illegible] about 27 lbs. per sq. ft., which applies to th[illegible] surfaces of poles and cross-arms. For the projected area of cylindrical conductors, one-half of this value, or 13½ lbs. sq. ft. was the factor used for the above wind velocity.

For standard straight line poles, Fig. 1, without side strains other than wind pressure, the corner angles are 3 × 3 × ⅜ ins. For the heavier strains at curves and corners, the general design of the poles is the same, but they are given greater strength by using heavier corner angles.

The design of the curve poles was made dependent on the distance by which the curve pole is offset from a straight line joining the two poles on either side of it. For offsets up to 6 ft. the corner angles of the pole construction are 3½ × 3 × 7/16 ins., while the offsets between 6 ft. and 10 ft. the corner angles are 3½ × 3 × ½ in.

The foregoing types of pole are each designed in the four lengths. By reason of the uniform taper, an extra length does not result in an increase of the size of the corner angles, but only in the enlarged dimensions of the base. The moment of resistance at the base being thereby increased in proportion to the height of the pole.

Besides the standard poles above described, designed to meet the ordinary conditions, an extra heavy pole was designed in three lengths. This type is called the strain pole and is used for offsets up to 32½ ft., for turning sharp corners or for anchoring the line at special points. These poles are similar in design to the standard poles, but the taper is uniformly increased to ½ in. to the foot, and all four sides taper uniformly all the way to the top, which is 8½ by 12 ins. The base of the 41-ft. pole is about 5 ft.

VIEW OF SECTION OF TRANSMISSION LINE, SHOWING STEEL POLES.

square, that of the 51-ft. pole being about 5 ft. 9½ ins. by 5 ft. 11½ ins. The corner angles of these strain poles are 4 by 4 by ⅝ ins.

All the poles are designed to withstand the side strains on 150 ft. spans due to the offsets above specified. For greater offsets the length of span is shortened. At all sharp turns, three

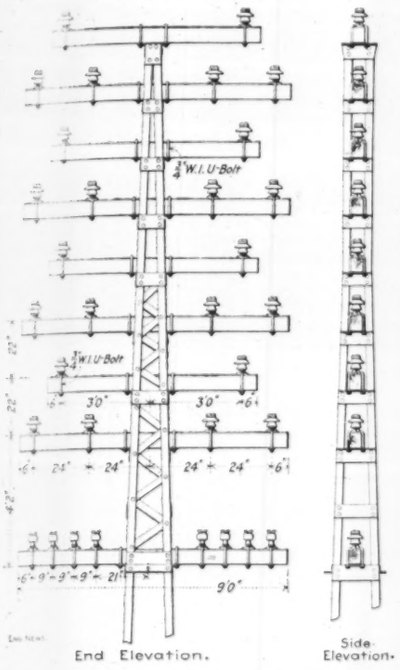


Fig. 1. Top of Steel Transmission Line Pole.

poles of the heavy strain type are used, two to take the longitudinal strains and guyed back to the base of the middle pole, which takes the side strains due to the offset.

The three first-mentioned standard types of poles were designed to take the necessary side strains without guying. The longitudinal strains due to anchoring the lines are so great, however, that the strain poles used for anchorage are guyed fore and aft to the bases of the adjacent poles with ⅞-in galvanized steel cable. On some sharp curves the poles were guyed laterally as an additional precaution, using ⅞-in. guy cable and Stombaugh guy anchors.

The construction of the steel pole includes angle iron seats for the cross-arms which pass through the pole structure, the weight of the cables holding the cross-arm down on the seats and requiring only the simplest type of fastening, which consists of two ¾-in. "U" bolts, which clamps the cross-arms immovably to its seat. The use of the ordinary type of cross-arm brace is rendered unnecessary. The ability of the steel pole to act as a lightning rod is turned to advantage, and each pole is thoroughly grounded to a copper plate buried beneath the foundation and connected to one of the anchor bolts by a copper wire.

The poles were transported from the steel works without "knocking down," and were erected whole upon their foundations with the aid of a gin pole. After erection, cement grout was run underneath the base and the pole permanently set by tightening the foundation bolts. There are now in position in the line 358 of the standard straight line and curve poles and 19 of the heavier type of strain poles.

The size of the concrete foundation varies with the height and character of the pole. For the straight line pole the dimensions are 4½ to 5 ft. square, averaging 8 ft. deep, with 1⅜-in. anchor bolts. For the curve poles, the foundations averaging from 4½ × 6 to 5½ × 7 ft. 3 ins. on the side faces, with a depth of between 7 ft. 9 ins. to 8 ft. 9 ins., and employing 1¾-in. anchor bolts. Strain pole foundations are from 7 to 8 ft. square, and from 9 to 10 ft. deep, and employ 1⅞-in. anchor bolts. The tops of foundations are usually about 9 ins. above the ground level. After the poles were all set and the line construction entirely completed, the box-shaped bases of all the steel poles were filled with concrete, brought up to a pyramidal form, as shown in the pole drawings.

WOODEN POLES.—The wooden poles are of two kinds: chestnut, which is the standard for ordinary work, and creosoted yellow pine, which is used only along the trestle over Jamaica Bay. The chestnut poles are 45, 50 and 55 ft. in length and 25 ins. in circumference at the top. The creosoted poles are from 60 to 80 ft. long, with the same dimensions at the top, and treated with 15 lbs. of dead oil of coal tar per cu. ft. of timber. Creosoted poles are all set 15 ft. into the bottom of the bay by means of a water-jet. They are all set so as to have the tops 30 ft. above the rails.

This method of pole construction along the trestle was adopted only after a most careful consideration of various ways that were proposed for carrying a line acros the bay. A separate trestle carrying a line of conduits made up as when laid in a trench was found too expensive. A pole line directly supported on the existing trestle would not afford the necessary clearance from traffic. Various plans were made for driving piles alongside the trestle and then splicing transmission poles to them, but even this construction, though practicable, does not compare in simplicity or durability with the long pole in one piece, which by the aid of a water-jet can be driven down into the mud butt first, instead of being treated as an ordinary pile, and driven point first.

This portion of the line is exposed in winter to a very severe strain due to the movement of the ice with the tide. The poles were set during a very severe winter, and the strains due to the ice were at times sufficiently great to cause the trestle to be moved out of line in places, but the poles set as above described successfully withstood the action of the ice. For a large part of this distance the trestle runs across a series of low islands which are covered with water at high tide only, so that it was difficult to reach them during construction, but with very few exceptions the poles were set by a floating pile-driving apparatus without going on the trestle or interfering with train operation. The total number of steel poles employed is 377, of chestnut poles 490 and of creosoted yellow pine poles 264.

CROSS-ARMS.—The cross-arms are of yellow pine, 5 × 6 ins. cross section, housed on top to a 12-in. radius, and they are painted with one

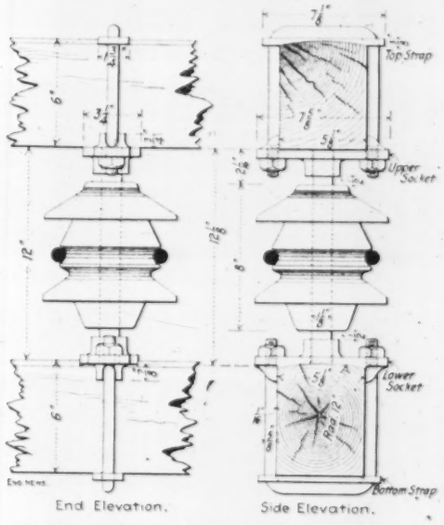


Fig. 2. Strain Insulators for Transmission Line Cables.

coat of asphaltum paint. The method of attaching them to the steel poles has already been described. On the wooden poles they are gained 1 in. into the pole and held by one ¾-in through bolt with 2-in. square washers. Bracing, though unnecessary on the steel poles, was effected in the case of wooden poles by angle iron braces made in one piece of 2 × 2 × ¼-in. angle bent into V-shape. For standard steel poles the arms are 7 and 9 ft. long. For steel strain poles, they are 7 ft. 10 ins. and 10 ft. 6 ins.

PINS.—The insulator pins consist of malleable iron castings clamped to the cross-arms by means of U-bolts threaded through the body of the pin, and held by a plate fitting over the U-bolts and against the cross-arm. This type was first used on this transmission line and represents a new departure in pin design, inasmuch as by its use all boring of the cross-arm is avoided. The strength of the cross-arm is maintained and the depreciation resulting from entrance of moisture through holes bored in the arm from top to bottom is obviated. The form of pin used is also of much greater strength than is possessed by a pin in which the bending moment where it enters the arm has to be met by small cylindrical cross section, which in case of the iron pin is sometimes not more than ¾ in. in diameter, and in a wooden pin 1½ ins. to 2 ins. The strongest part of this pin is at the base where it joins the cross-arm. It admits of easily following up any shrinkage of the cross-arm (which cannot be done in a pin which is set in a hole in the cross-arm), as all that is necessary, if the pin comes loose, is to tighten up the nuts on the underside of the clevis.

INSULATORS.—The straight line insulators are 6½ ins. in diameter and 5 ins. high, made of porcelain in two parts connected together. The insulators are colored with a brown glaze to render them less conspicuous. They are designed particularly for the conditions here imposed. The pin and insulator together carry a 250,000 c. m. cable 6½ ins. above the cross-arm. The ties are made of ordinary soft copper wire, tied on top. The tests to which the insulators were subjected at the factory include a rain test of 30,000 volts and a salt water flash test of 50,000 volts for two minutes. The insulators were further obliged to pass the test of plunging them into hot water

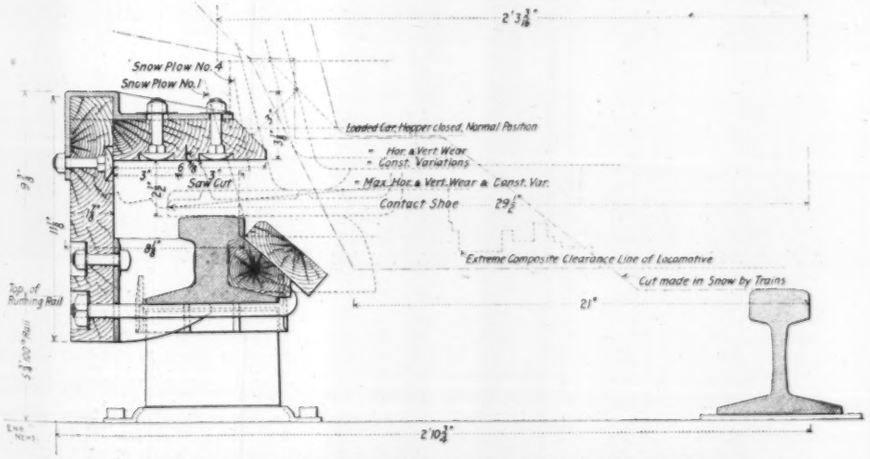

Snow Plow No. 4
Snow Plow No. 1
Loaded Car, Hopper closed, Normal Position
= Hor. & Vert. Wear
+ Const. Variations
= Max. Hor. & Vert. Wear & Const. Var.
Saw Cut
Contact Shoe
Extreme Composite Clearance Line of Locomotive
Cut made in Snow by Trains
Top of Running Rail
21"

FIG. 3. DETAILS OF THIRD RAIL GUARD AND SUPPORTS.

and then into ice water without cracking. After the insulators were erected and the cables strung upon them ready for operation they were tested by applying 30,000 volts between the conductor and the ground for four minutes. The insulators underwent all these tests successfully.

The strain insulators are of the "spool" type and made in one piece 7½ ins. in diameter and 8 ins. high. Each strain insulator has two petticoats, one above and one below the point where the wire is attached. A 1⅛-in. by 12-in. steel pin is cemented in the center of the insulator, and this steel pin rests in sockets at the top and bottom, which are firmly clamped by U-bolts to the cross-arms. This obviates the boring of arms, and thus preserves consistency with the design of the straight line insulator pins. The drawing in Fig. 2 illustrates the method of attachment.

The insulators were cemented on to the pins before erection. The cement used throughout was composed of litharge moistened with a mixture of glycerine and water. This type of cement was found after careful trials to be preferable to Portland cement, and although the materials were more expensive, it was found that the labor cost of doing the cementing and the risk of breakage were so much less as to more than counterbalance the extra cost of material. The steel bolts that constitute the pins upon the strain insulators were cemented in the same manner. The pin was first wrapped with lead foil to prevent cracking due to possible expansion of the pin.

TYPE OF THIRD RAIL CONSTRUCTION.—In the selection of the general type of third rail construction, the requirements were that both the rail and the contact device must be suitable for collecting heavy currents at any speed; the rail must be so placed as to encroach as little as possible beyond the fixed clearances of the permanent way, and it must clear all forms of equipment in general use on the road. The design of mounting must be mechanically stable, and besides including good insulation must provide a reasonable degree of protection to employees against accidental contact and be proof against interruption of service by weather conditions. It was also desired to settle upon a standard form and location of rail that would permit a free interchange of ordinary passenger and freight equipment between the Long Island R. R. and other roads in the vicinity.

A study of the equipment clearances (Fig. 3) pointed to the necessity of locating the third rail with its gage line 26 ins. from the inside of the gage line of the running rail and its top at a

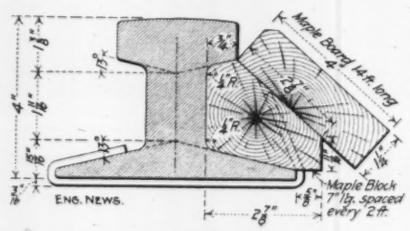


Fig. 5. Standard Wooden Side Approach Block Construction.

height of 3½ ins. above the top of the track rail. After considering a great variety of designs, both of rails and contact shoes, it was decided to adopt the top contact type which is now almost universally employed. In order to best combine the qualities affording protection to employees and immunity to weather troubles, it was decided to provide a horizontal type of guard extending directly over the rail, requiring the use of the slipper type of contact shoe. With this type of contact rail, a tee section was naturally adopted on account of its stability. The location of the contact rail with reference to the track was also governed by the fact that it could not be placed much farther away from the track rail without interfering with bridge gussets and other fixed objects, while if placed higher the guard would be interfered with by 50-ton hopper bottom steel coal cars when heavily loaded.

The rail used for most of the conductor line is a T-rail 4 ins. high, 3-in. head and 6-in. base, weighing 100 lbs. per yard. The rail is rolled from extra soft steel, in 33 ft. lengths and connected up by four-hole splice bars.

The rail is supported every 10 ft. on [illegible] clay insulators set on extra long ties. [illegible] sulator (Fig. 3) consists of a cylindrical [illegible] vitrified clay with a beveled flange proje[illegible] the base and a 2-in. hole through the [illegible] aid in manufacture. A malleable iron [illegible] ing two projecting lugs and holes in [illegible] for lag screws, fits over the flange at th[illegible] the insulator, two lag screws being use[illegible] ten it to the tie. Resting on top of th[illegible] tor is a malleable iron cap which proje[illegible] over it for a distance of 1⅛ in. and has [illegible] 1¼ ins. long projecting upwards. The r[illegible] on top of the cap between the ears. W[illegible] type of insulator, no vertical strain com[illegible] it due to the sagging of the tie when [illegible] passes, as the rail is in no way dire[illegible] attached to it. The design also facilitates [illegible] removal of broken insulators, as the whol[illegible] may be removed by taking out two lag [illegible] in the base. There being four different [illegible] running rails and three sizes of third r[illegible] the dimensions of the insulators are made i[illegible] three sizes to suit the conditions. Two of them are 6 ins. in diameter and 3⅞ ins. and 5⅞ ins. high respectively, the other being 4½ ins. in diameter and 3⅝ ins. high, but of the same general form. In this way the proper height of third rail above the running rail is maintained.

The end approach blocks and incline for lifting the third rail shoes are of cast iron. Two lengths are used, one being 5½ ft. long and used on main line tracks, where the shoes must be raised and lowered at high speed; while the other, which is 2½ ft. in length, is used only on spur tracks and sidings. The approach blocks are attached to the end of the rails by the regular splice plates and are supported on standard third rail insulators at their outer ends. The general design and arrangement of the approach blocks in position is shown by Fig. 8. The side approach blocks used at switches are of wood, and were chosen in preference to metal blocks because the blocks must project several inches sidewise from the third rail beyond the guard, exposing trackmen to danger if made of metal. The wooden block consists of a piece of maple 1¼ ins. thick and 5 ins. wide, set at an angle of about 45° on

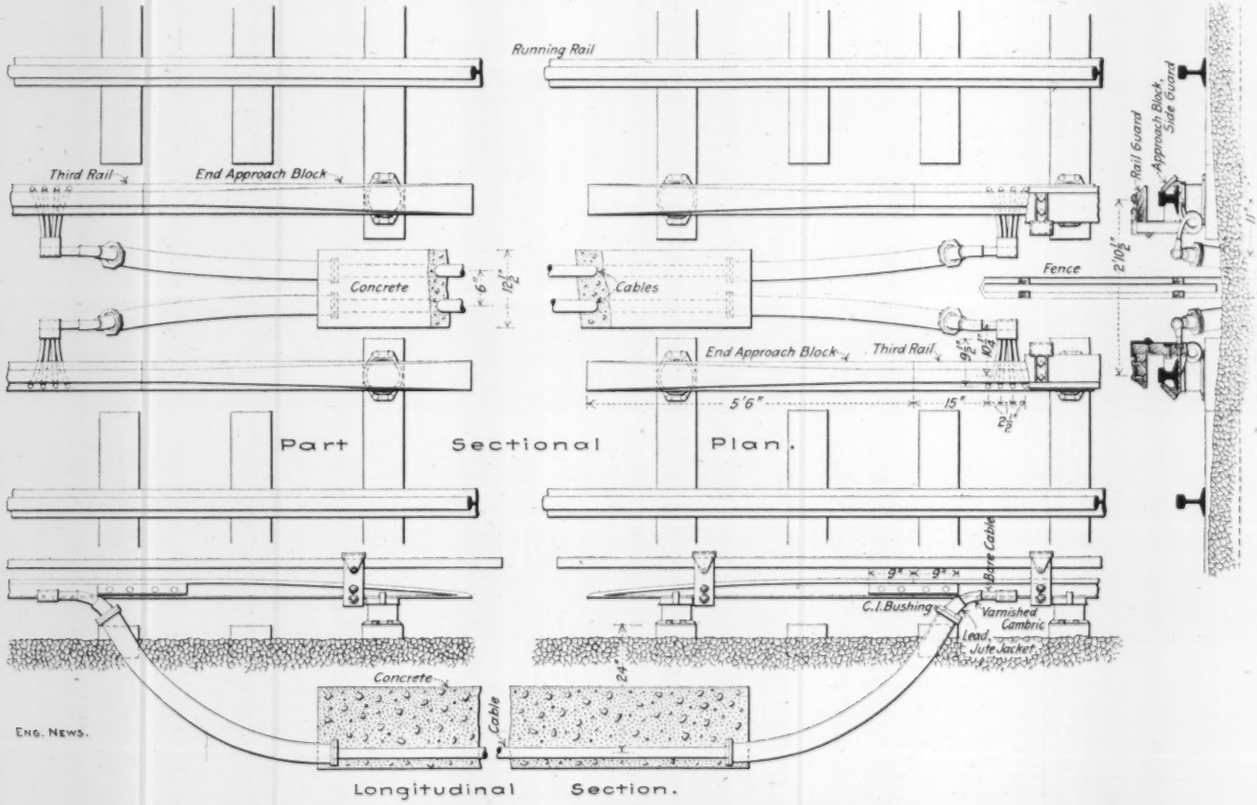


FIG. 4. STANDARD ARRANGEMENT OF THIRD RAIL CONNECTING CABLES AT PUBLIC CROSSINGS.

the side of the rail, as shown in Fig. 5. This strip of wood is about 14 ft. long and is nailed to maple blocks which are set against the web of the rail, spaced at intervals of 2 ft. A 7/16-in. × 1-in. steel strap, which fits into the block, holds it securely in place, being fastened underneath the foot of the rail, and clinched over it, thereby avoiding drilled holes and unnecessary expense. The side approach blocks, although subjected to severe service, demonstrated their durability.

The third rail joints have laminated copper foot bonds with plug terminals. At highway and other public crossings, where the third rail has to be interrupted, underground jumper cables are installed. Fig. 4 shows the standard arrangement of running and connecting up the jumper cables. The ends of the cables come to the surface through curved 3½-in. iron pipes fitted with regular conduit bushings, and extending about 6 ins. above the surface of the ground. The ends of the conductors are connected to the third rail by having sweated upon them special brass terminal lugs, each lug having sockets for four 400,000 c. m. flexible cables. Short cable bonds each with a copper plug terminal drop forged on one end, are soldered into the socket, and after pigtailing these terminals to provide flexibility the plug terminals are compressed into holes in the base of the rail. The number of bonds used in each case varies with the size of the cable, being four for the 2,000,000 c. m. cable, two for 1,000,000 c. m cable and one for the 500,000 c. m. cable, in which case the bond is soldered by means of an ordinary sleeve connection to the cables.

The Stilwell-Slater type of guard was adopted for the third rail; it consists of yellow pine plank 1⅞ ins. thick, 7 ins. wide, placed above the rail with 2½ in. clear space between the top of the rail and the under side of the plank. The edge of the plank nearest the track extends ⅞ in. beyond the line of the third rail head, and is beveled back to give the necessary clearance for running equipment. Each plank has a saw cut ⅜ in. deep in the middle of the underside to prevent warping. The planks vary in length from 14 to 16 ft. The guard is supported directly from the third rail, there being four supports to each plank. The planks are butted together without splicing so as not to interfere with the free expansion and contraction of the rail and to facilitate repairs. Fig. 7 shows the guard in complete detail. The supports consist of upright posts of oak and chestnut 1⅞ ins. × 3⅞ ins. × 11 ins. long carrying on top a malleable iron cap which fits down over the top of the post and held to it by a carriage bolt. This cap has a projecting bracket against the under side, of which the guard plank is fastened by two carriage bolts with heads countersunk on the underside of the plank. One of the bolt holes in the iron cap is slotted transversely so that the plank may not split by shrinkage. The wooden post is carried on a malleable iron casting which fits closely against the web and around the bottom flange of the third rail so that a single hook bolt engaging with and passing under the bottom flange of the rail clamps the guard post firmly to it.

Additional protection is provided for the third rail at stations. This consists of a yellow pine strip 4 ins. wide and 1¼ ins. thick set at an angle of about 45° with the rail and almost completely covering the side of it. This strip is nailed to wooden blocks fastened to the web of the rail in a manner similar to that used on the side approach blocks. Where necessary this side guard is placed on both sides of the third rail, thus reducing the chance of workmen coming in contact with them. At station platforms protection is also provided against car shoes, whether there is a third rail close to the edge of the platform or not. This protection consists of a 2 × 7-in. yellow pine plank supported by malleable iron castings, the top being nearly on a level with the platform. These castings rest on the ties and are spaced 6 ft. apart. This guard is so located that there is plenty of room underneath for the third rail shoes.

The design and construction of the transmission system was carried out by Westinghouse, Church, Kerr & Co. and the entire work was under the direction of Mr. George Gibbs, Chief Engineer of Electric Traction of the Long Island Railroad, subject to the approval of an Electrical Committee, consisting of the chief operating officials of the road, with the President as Chairman.

MR. JOHN F. WALLACE'S STATEMENT IN REPLY TO SECRETARY TAFT.

In our issue of March 1 we published an extended abstract of Mr. Wallace's statement before the Senate Committee relating to the circumstances of his separation from the canal enterprise, in the course of which statements were made reflecting on Secretary Taft and Messrs Shonts and Cromwell. In a more recent issue (May 10) we published Secretary Taft's statement to the Senate Committee regarding these and other matters.

Mr. Wallace has now submitted to the Senate Committee a rejoinder to Secretary Taft's statement, and we take from it the following extracts:

I first desire to call attention to the fact that under date of June 11, 1905, Governor Magoon (in the letter quoted by Secretary Taft) advised Secretary Taft that he, Magoon, could "not escape the conviction that Wallace is trying to 'pull off' a carefully-contrived coup d'etat." Two days later, under date of June 13th, Governor Magoon again advised Secretary Taft that he, Magoon, was "inclined to think I judged Wallace too harshly in concluding that he was attempting to 'squeeze' you." And nine days later Governor Magoon furnished still another version of his impressions, stating "that Wallace is not attempting a 'squeeze,' but honestly thinks he is entitled to supreme place and power," and added: "He asked me to telegraph Secretary advising his retention on Commission as one of the four engineer members. I will comply, believing retention advisable."

From the testimony of Secretary Taft it would seem that he prejudged my motive on inaccurate and ex-parte statements, particularly the first letter of Governor Magoon's.

It is submitted that the letters and telegram of Governor Magoon show that he was not positive in his own mind at that time as to my contemplated action or motives therefor. It is needless to add that the impressions he claims to have received were never intended to be conveyed by me, and that his recollection of the interviews is, to say the least, quite misleading.

Governor Magoon, in our conversation on the Isthmus, himself suggested to me that I should request Secretary Taft to appoint me Chairman of the Commission, adding that Secretary Taft, when selected as a member of the Philippine Commission, had refused to serve unless placed at the head of the Commission, necessitating the withdrawal of the name of another as chairman, and that he, Magoon, believed under the circumstances such a proposition would appeal to him. I replied that I would make no demands upon Secretary Taft, that Mr. Shonts was my personal friend, and that I much preferred, as Governor Magoon admits, going to Mr. Shonts and "putting it to him straight." I also requested Governor Magoon to make no suggestions to Secretary Taft, but I note from his cablegram to Mr. Cromwell that he was under the impression that I desired him to recommend my retention as an engineer member of the Commission, and this despite the fact that Governor Magoon assured me he would regard the subject as confidential and give me an opportunity of first presenting the matter to Secretary Taft in a personal interview. The breach of confidence upon the part of Governor Magoon, in advising me to take a certain line of action, and then, presuming that such advice would be followed, secretly writing to Secretary Taft as to what he thought I would probably do, speaks for itself.

Secretary Taft in his testimony before your committee characterizes as an untruth the statement made by me in my letter addressed to him under date of June 8, 1905, that at no other time during the year would the work on the Isthmus be in a better condition to permit of my absence. This was my judgment on each and every occasion specified and still is my firm conviction.

The facts about Mr. Dauchy, Division Engineer at Culebra, are the exact contrary of the assertions of Secretary Taft. Mr. Dauchy has had experience in the transportation department of railroad work in addition to being Chief Engineer of the Rock Island System (the same position afterwards held by Mr. Stevens) and whenever occasion required he was designated on the Isthmus as Acting Chief Engineer by me with the full approval of the Isthmian Canal Commission. Mr. Dauchy was not only perfectly capable of carrying on the work of organization, but, in my judgment, he could have easily controlled the situation under the improved conditions which existed at the time I left the Isthmus, if he had not been summarily deprived of the power to do so through the actions of Governor Magoon and the authorities at Washington. He was not appointed Assistant Chief Engineer for the simple reason that it was not intended to fill this position by the appointment of any one except an engineer fully qualified for the duties of the position during the entire construction period of the canal. It is true that several high-class assistant engineers were needed, and every effort was being made at the time to secure them, and it was my intention to personally select these men on my return here, as stated in my letter of June 8, 1905, to Secretary Taft.

The personality of Mr. Shonts had nothing whatever to do with my conclusions as to the situation existing, as we had been life-long friends, and it was my endeavor to have our relationship so continue even after the tender of my resignation, and the question of his personality was entirely apart from what I could not accept, namely, in addition to Mr. Cromwell's domination that of Mr. Shonts, in accordance with his verbal understanding with the authorities in Washington, all of which was contrary to the wording and spirit of the executive order defining the duties of the Commissioners. I fully concede both Mr. Cromwell's and Mr. Shont's perfect right to accept such authority over me, but Secretary Taft well knew that I could not serve in such subordination to both or either of them.

I wish to reiterate the fact that financial reasons were not the cause of my request to be relieved of the work, and that my desire for proper authority and non-interference with the conduct of the work was not due to personal ambition, but I considered such a condition absolutely essential to the speedy and economical completion of the canal, and that the power and responsibility should be properly united in me or my successor. The principal sense in which salary, either in governmental or civil positions, has ever appealed to me has been due to the fact that to a great extent it measured the public estimation of my work in my profession.

At no time did the thought ever occur to me to "hold up" Secretary Taft or any one for additional authority or compensation, and additional authority and compensation could only have appealed to me if they had come unsought and without solicitation on my part.

RAILS 331 FT. LONG were exhibited at the International Exhibition held at Liege, Belgium, in 1905. These included an 85-lb. grooved girder rail for street railway track, 331.28 ft. long, and a 70-lb. tee rail of the same length; also a light tee rail 252.56 ft. long, of only 7 lbs. per yd., for portable railway track. The two large rails were each made from a 5½-ton ingot, heated 1½ hours in the soaking pit to insure a uniform temperature throughout the mass. This was rolled in a rolling mill having blooming and finishing mills driven by an engine of 10,000 HP.; the rail was rolled in five minutes, and was exactly 354.24 ft. long., the ends being cropped to make a first-class rail of 331.28 ft. Owing to the restricted space, the rail, as it passed through the rolls, traveled up a steep inclined plane and over the top of a two-story building. When the rolling was finished, and while the rail was still at a bright red heat, it was attached to a locomotive which hauled it along the ground about 650 ft. to a place where it could be left to cool slowly. These rails, as well as two tires 16.4 ft. diameter, were exhibited by the Ougree-Marihaye Co., of Belgium.

TWO HEAVY ROLLING MILL ENGINES for the Carnegie Steel Company, Sharon, Pa., larger than any heretofore built, are now being constructed at the West Allis Works of the Allis-Chalmers Co., Milwaukee.

The engine frame and slide for the first engine was recently cast at the West Allis foundries, and was the largest and heaviest single piece ever poured in these shops. The single piece for frame and slide weighed roughly, 105 tons and is designed for an engine whose cylinders will measure 50 ins. and 73 ins. in diameter with a stroke of 60 ins.

The pattern for this single casting measured 32 ft. long, 11 ft. wide and 10 ft. high, representing the work of ten expert pattern makers for a period of over four months. The amount of lumber used in its construction reached the surprising aggregate of over 22,000 ft. The pit in which the casting was poured measured 40 ft. long, 15 ft. wide and 11 ft. deep, and the pouring of the 105 tons or more of moulten metal consumed eight to ten minutes' time. Nine ladles, four with a capacity of 25 tons each, one 13 tons and four 5 tons each, were used in the operation.

Three cranes with a rated aggregate capacity of 145 tons were used in conjunction to lift the casting from its pit, a special tackle being devised so that the lifts should be straight upward. The casting, after being deposited beside its pit, was allowed to cool for 15 days before the operation of cleaning it was begun. The heat still given off after approximately 20 days' cooling, could be felt several feet away from the huge mass.

In anticipation of the difficulty of handling a piece of this size, special cars (Eng. News, May 24, 1906) were ordered some months ago. After cleaning, the casting was placed upon one of these cars and taken to the machine shop, where it was placed upon the floor and the heavy machine tools used in machining are brought to it.

BLOCK AND INTERLOCKING SIGNALS IN THE ELECTRICAL ZONE OF THE NEW YORK CENTRAL & HUDSON RIVER R. R.

The plans for block signaling and interlocking in the electrical zone of the New York Central & Hudson River R. R., at New York City, are perhaps the most novel and extensive ever developed for an American railway. Both block and interlocking work will be all-electric operated by current taken from a power line running the whole length of the system. All track and signal circuits will be operated by alternating current; the only batteries to be used being storage batteries for the operation of interlockings, which will be charged by an AC-DC motor generator drawing current from the power line. In the following paragraphs the typical and novel features only of the system are described and illustrated, as the extent of the work makes a description in reasonable space of all even of the more interesting details impossible. The description presented is prepared from information furnished by the New York Central & Hudson River R. R., Mr. W. J. Wilgus, M. Am. Soc. C. E., Vice-President.

DEVELOPMENT OF PLANS.—Track plans showing the spacing and arrangement of all signals were prepared by the railway company, and together with specifications were submitted to all of the signal companies capable of handling the work. Separate bids were requested for the block signaling and the interlocking work.

To assist in finally deciding the system to be adopted, bids for block signaling were requested in eight different forms, covering both normal clear and normal danger systems, all-electric and electro-pneumatic design, and either with one rail of each track given up for signaling purposes or with both rails left available for power return. Bidders were encouraged to make suggestions as to design and requirements of specifications, so that the specifications might not be considered to act as a restriction on the exercise of their best skill.

In canvassing the proposals the signal committee of the New York Central lines was called into consultation, and every feature was gone over in detail. The system offered by the General Railway Signal Co., and known as the "Young System," was adopted. Alternating current is used for track circuits in connection with reactance bonds, permitting the passage of the direct propulsion current freely through both of the running rails, while impeding the alternating current used in signaling. This two-rail system was deemed best suited to the conditions.

SCOPE OF THE WORK.—The work included by the contract covers what is known as the "Electric Zone," extending from the Grand Central Station to Croton, on the Hudson division, a distance of 35 miles, and from Mott Haven to White Plains, on the Harlem division, a distance of 19 miles. Throughout this distance there will be four main tracks, and the work includes about 3,000 interlocking levers and 1,400 track circuits, aggregating about 250 miles. The work to be undertaken at the present time covers only that portion of the road to be electrified this year, which carries the work from the Grand Central Station to High Bridge on the Hudson division, and to Wakefield on the Harlem division.

Fig. 1 shows the general arrangement of tracks in the electric zone, the two main power stations at Port Morris and Yonkers delivering three-phase alternating current of 25 cycles and 11,000 volts pressure, and the various sub-stations at which this current is transformed and converted to direct current at 666 volts for delivery to the third rail for operating purposes. These sub-stations are also equipped with the transformers for the signal service, delivering alternating current at 3,000 volts to the signal transmission line, which, although extending the entire length of the district to be signaled, is cut half way between each pair of sub-stations, thus making that portion of the line fed by each sub-station entirely independent of the adjoining one.

The apparatus in each sub-station is properly protected with automatic and hand operated switches, and in order to insure operation, should the alternating current fail, DC-AC motor generators taking current from the storage battery

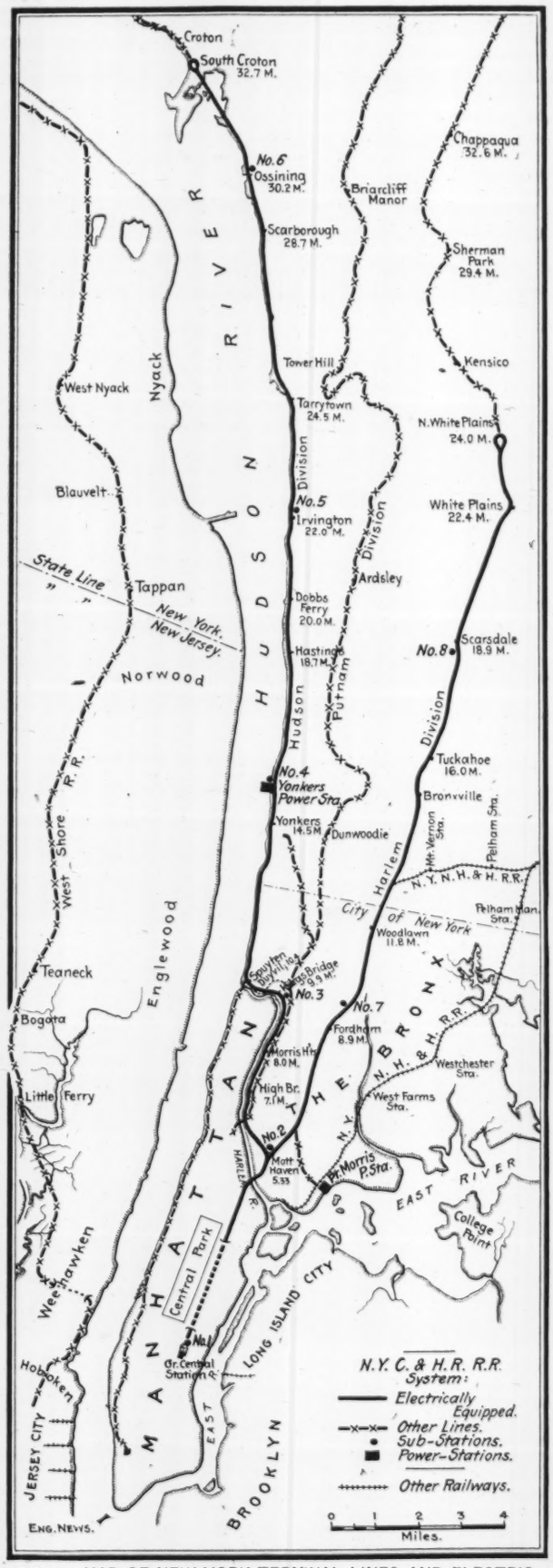


FIG. 1. MAP OF NEW YORK TERMINAL LINES AND ELECTRIC ZONE, NEW YORK CENTRAL & HUDSON RIVER R. R.

system installed in ... sub-station for use of tr... will continue to feed the sig... transmission line with a... rating current, and the sign... system will continue to work ... er all conditions under whi... traffic will be operated. A sy... onizer is installed between ... transformer and the motor ... erator set.

TRANSMISSION L... —The 3,000-volt transmission ... e consists of No. 0 bare co... wire, carried on the pole li... and in the conduits used for ... main transmission system. Fig. ... shows the design of the poles ... ed for the transmission line ... side of the thickly populated ... stricts. Signal bridges are equi... d with extension brackets, w... cross arms, for convenience i... running wire lines to signals.

For the operation of ... al circuits, signal motors, ... licators and signal lighting, th... 3,000-volt current is stepped ... down to 50 volts, through tra... formers placed on signal bridges ... transmission line poles. The ... secondary of the transformer is ... provided with a ground co... nection, formed by burying a 2 ... 3 ... in. copper plate, to which is brazed a No. 4 B & S gage copper wire.

For track circuit operation the voltage depends on the length of track circuits, and varies from 1½ volts for circuits of 200 ft. to 8 volts for circuits of 5,000 ft. The reduction from 50 volts to the track voltage is made by a transformer provided with four taps, which will permit of one type of transformer being used on all track circuits.

In laying out the block signaling plan, the length of the block was determined by the braking distance. For speeds not exceeding 45 miles an hour the blocks were made 1,200 ft. long; for speeds between 45 and 60 miles an hour 2,500 ft., and for speeds over 60 miles an hour 3,000 ft., the average length of the long blocks being about 3,200 ft. All blocks have a full block overlap. A distant signal is provided for each home signal. On account of the density of traffic and the necessity for quick operation the clearing time is limited to three seconds.

TRACK CIRCUITS. — The track circuits are of three types, as shown in Figs. 3, 4 and 5. Where they are 500 ft. or less in length, and where the drop in potential in the length of the track circuits is not greater than 50 volts, the "one-rail" system is used, and one rail of the track is given up for signaling purposes, and the arrangement shown in Fig. 3 is used. There being no direct cur... at on the signal rail it is not necessary to use any reactance bonds.

On all track circuits over 500 ft. in length the "two-rail" system is used, and both track rails are used for the return of the direct power current, and on all of these circuits it is necessary to use the reactance bonds, by which the connection is made around the insulated rail joints, permitting the direct current used in operating

to pass, while impeding the alternating current used for track circuit work. The insulated rail joints are of the Weber pattern with a steel angle plate on the inside.

On track circuits between 500 and 1,600 ft. in length the "two-rail" system is also used and the reactance bonds consist of a copper bar 1 in. in cross section and 30 ft. long coiled in eight turns around an iron core, as illustrated in Fig. 6, the arrangement of the circuit being as shown in Fig. 4. For track circuits over 1,600 ft. in length a reactance bond formed of a coiled copper bar without any iron core is used; the circuit being illustrated in Fig. 5.

It will be seen that the block sections are of two types, the one-rail and the two-rail systems. In the former the propulsion current flows along the continuous rail, and in the event of a defect in the continuous rail, this current must avail itself of the conductivity of adjacent tracks, through cross bonding. In sections of the two-rail system each of the traffic rails of a track forms separate and independent conductors so that if one rail is interrupted the other would act as a return conductor, even if there were no cross bonding to adjacent tracks.

The use of two styles of bonding was determined by the cross bonding for the electric traction system. The Engineering Department of the railway company determined that the distance between such cross bonds should not exceed 1,600 ft. For blocks that are 1,600 ft. or less in length the type of bond shown in Fig. 6 allowing cross bonding at the ends of the track sections was best suited to the conditions. For track circuits over 1,600 ft., the ironless reactance bond, illustrated in Fig. 5, is the least expensive and the one to be used.

In Fig. 7 is shown the proposed arrangement of the reactance bonds on all four tracks, and also the connections from the bonds to the rail, which consist of bare stranded copper cable 1,-200,000 circular mils. The specifications require that the connections shall not be made within 2 ft. of the rail joint, and that 2 ft. of slack shall be allowed to provide for creeping of rails.

All of the reactance bonds are enclosed in water-tight cast-iron boxes set on foundations, the boxes are filled with oil to carry off the heat generated. The bond is designed to permit the continuous passage of 3,000 amperes for each rail of the track without injurious heating. The casing of the box is made to cover the terminals and connections to the rail to keep them from being tampered with.

The track relay is of the induction motor type with two field coils. One coil is energized by the 50-volt signal operating current which gives the greater part of the energy required to magnetize the fields and armature. The other coil is energized by the current from the track rails and this current need only be strong enough to give sufficient magnetism to rotate the armature. The armature revolves through an angle of 37½°, during which movement the contacts are separated through 23½° and made up through 14°, thus giving a good rubbing contact. Especially hard carbon is used for the fixed point of contact, while the moving point is of platinum. As the controlled current is an alternating one, there is little sparking, although currents of from 1/16 to ¼ HP. are used.

The box containing the track relay and transformer and the grid resistance has a plug in which an electric light can be cut in for use in night inspection.

SIGNALS.—The signals are to be of the General Railway Signal Co.'s motor operated type, with mechanism placed in the base of the signal mast, and worked by a single-phase alternating motor of ¼ HP., using current at 50 volts. The general arrangement of the mechanism is shown in Fig. 8. The slot mechanism is exceedingly simple, and under alternating current operation is very quick in releasing.

The signals are of the 60° two-position type, using New York Central standard spectacles and blades, which impose on the signal motor a load equal to the lifting of a 17 lb. weight, at a distance of 4 ft. from the center of the shaft. With this load the motor will clear the signal in from two to three seconds. Square end blades are used on home signals at interlockings, and pointed end blades on automatic home block signals.

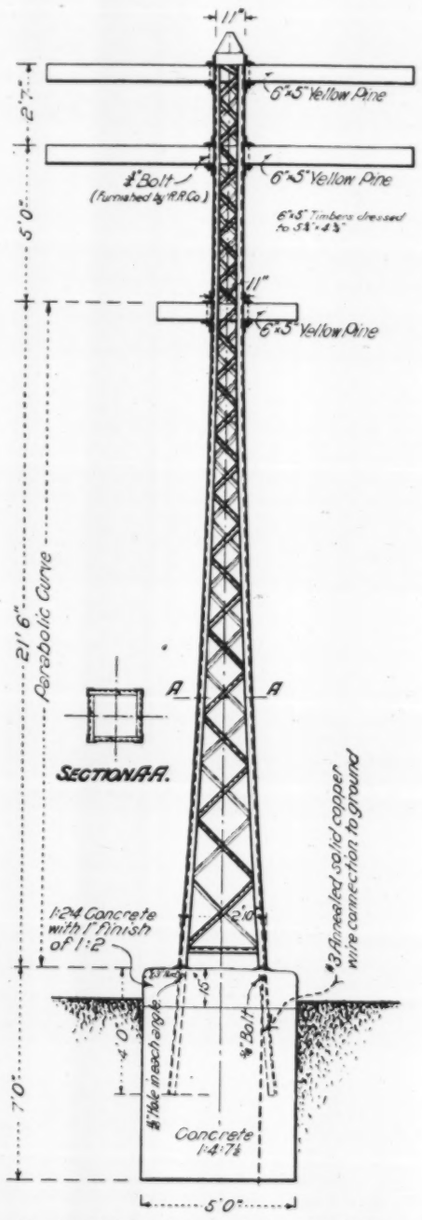


Fig. 2. Details of Transmission Line Poles.

4 angles ..... 3 × 3 × 5/16-in.
Lacing one angle ..... 2¼ × 1½ × 3/16-in. (single)
Conn. angles ..... 2½ × 2½ × ¼-in.
Cap Plate ..... Malleable Iron
Rivets ..... ¾-in. diam.
Estimated Quantities:
Steel ..... 1,340 lbs.
Concrete ..... 6.5 cu. yds.
Timber ..... 71 ft. B. M.
General Conditions:
Distance C. to C. of Poles = 150′ on Tangent, Sag = 30″
Distance C. to C. of Poles = 141′ on 1° Curve, Sag = 27″
Distance C. to C. of Poles = 133′ on 2° Curve, Sag = 24″
Distance C. to C. of Poles = 125′ on 3° Curve, Sag = 21″
Distance C. to C. of Poles = 118′ on 4° Curve, Sag = 18½″
Distance C. to C. of Poles = 112′ on 5° Curve, Sag = 16½″
Distance C. to C. of Poles = 107′ on 6° Curve, Sag = 15″
Sag of wires for all spans computed at + 70° F. with no wind.
Load on Poles:
6 Wires, Circuit No. 1, each 0.728″ dia. area = 400,000 C. M., weight 1.22 lbs. per lin. ft.
4 Wires, Circuit No. 2, each 1.5″ dia. area = 1,000,000 C. M., weight 3.55 lbs. per lin. ft.
3 Wires, Circuit No. 3, each 0.165″ dia. area = 27,225 C. M., weight .074 lbs. per lin. ft.
together with ½″ coating of ice on all wires.
Wind pressure 30 lbs. per sq. ft. on the surface of the pole, and on all wires covered with ½″ coating of ice.
Unit Stresses:
Tension = 30,000 lbs. per sq. in. net section.
Compression = $1 + \frac{30{,}000 \text{ lbs.}}{\frac{l^2}{125\ r^2}}$ per sq. in. gross section.
Shear on Rivets = 22,500 lbs. per sq. in.
Bearing on Rivets = 45,000 lbs. per sq. in.
Maximum bending moment on pole = 2,910,000 in.-lbs.
Maximum overturning moment of pole = 3,340,000 in.-lbs.
Specifications:
Material to be in accordance with clauses 9 and 10 of Manufacturers' Standard Specifications for Open-Hearth Steel as given in the Carnegie Steel Co.'s Pocket Companion, dated 1903.
Workmanship to be in accordance with the said specification for workmanship.
Painting to be one coat of N. Y. C. standard red lead paint on each surface in contact before assembling; and one coat on the entire pole before leaving the shop. Before erection add two heavy coats of N. Y. C. asphaltum varnish.
Note.—Cross arms and ground wire with ⅝-in. bolt, will be furnished by the Railroad Co.
Top of Foundation 6 ins. above base of rail in cut.
Top of Foundation 6 ins. below base of rail on fill.
Note.—Finish top of pedestals as indicated to keep water away from steel work and to shed from center towards sides of pedestals.

The signal lamps are New York Central standard pattern, and are provided with an electric light attachment, as shown in Fig. 10. The lamps are of four-candle power, working on a 50-volt circuit, and are connected in parallel, with a fuse cut out, to allow any lamp to be disconnected without affecting other lamps supplied on the same circuit. The filament of the lamp is wound in a small circle, to bring the point of maximum illumination within the focus of the lens.

The signals to be used in the Park Ave. tunnel will consist of lights only, without any moving parts whatever. Electric lights will be arranged in a box behind lenses of proper color, and the current for the lamps will be directly controlled by the relay contacts. Lamps giving the proper color for the stop or caution indication will be lighted when the track relay is de-energized and those giving the proceed indication will be lighted when the relay contact is closed.

With this installation the colors used by the New York Central for the night signal indication will be changed in the electric zone, and instead of using white for proceed and green for caution, the system of using green for proceed and yellow for caution will be used for the first time on this line.

TYPICAL INTERLOCKING PLAN.—A typical plan of an interlocking is given in Fig. 11, which shows the plant to be installed at Bronx Park. These interlockings are of the standard type, manufactured by the General Railway Signal Co., in which direct current, furnished from storage batteries is used to operate the switch movements and signals. As usual with this type of apparatus the indication is given by the current formed by the motor, which on completing its stroke at the signal or switch movement is changed to a generator and gives sufficient current to release the lock of the lever of the machine.

The current to charge these storage batteries is to be obtained from an AC-DC motor-generator set, taking current from a transformer fed from the 3,000-volt signal transmission line and furnishing current of 150 volts.

The storage battery consists of 55 cells of capacity varying from 80 to 320 ampere hours, according to the number of daily lever movements to be made. The average time between charging will be four days. The motor generators with switchboards will be placed in the basement of tower buildings and a separate battery house will be provided to keep the fumes of the batteries away from the signalmen and the apparatus in the towers.

The interlocking machines are of the usual type made by the General Railway Signal Co. and are provided with a latch for each lever to require a definite action on the part of the operator to change the position of the lever. The lever handles are colored according to their functions. There will be a separate lever for each high signal arm and no selectors will be used. Two switches may be controlled on one lever with circuits arranged as shown in Fig. 12.

The interlocking signals will be of the General

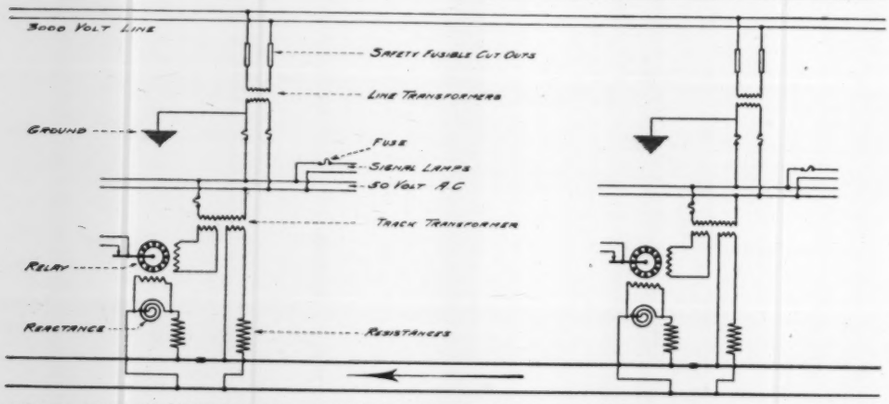


FIG. 3. TYPICAL ALTERNATING CURRENT TRACK CIRCUIT, ONE RAIL GIVEN UP FOR SIGNALING PURPOSES.

Railway Signal Co. type with dynamic indication current return. These signals, where slotted, will return to the stop position when the current through the slot magnet is open, but the return indication from the signal motor is not received at the lever until the lever is first restored to the normal position. The operating circuits for the signals are run through controllers on all facing switches in the maine line, insuring that the switches are properly set before the signals can be cleared. Block signals on the same mast with distant signals are controlled by a lever in the machine requiring the block signal to be changed to the stop position before a signal can be cleared for a reverse movement on the main line.

The advance signals for each track, although operating as automatic block signals, are controlled from the interlocking and are provided with a square end blade to enable the signal man to hold a train, if it is desired to do so.

Approach locking will be provided for all main line switches. This locking becomes effective when a train has reached a point at least one mile in the rear of the distant signal.

In order to permit the signal man to change the route for a train in case of a mistake in setting it up, a mechanical screw release is provided. This will allow the releasing of the lever and changing the route on the expiration of a time interval of 1½ minutes after the signals have been restored to the stop position. A counter reading to five figures is to be placed on all high signals to register the number of movements.

The movement to be used to operate the switches is of an entirely new type and is shown in Fig. 13. With the small clearance under the third rail contact shoe, a mechanism that will not project above the top of the running rail is absolutely necessary. This movement is enclosed in a casing with the gear and ascapement crank horizontally arranged. The reversible pole changer and indication switch box are also enclosed in the casing with the switch mechanism, protecting these parts. The movement is fitted with an improved locking device which, in the case of the plunger catching on the locking rod, as it will do if the switch does not lock up properly, will release the plunger, allowing it to stop while the main part of the movement completes its stroke. The arrangement prevents the motor from forcing the plunger through the lock rod in case it should not have come to the proper position.

The type of dwarf signal to be used is a new one, the signal arm being moved by a motor mechanism arranged horizontally at the base of the post. With this apparatus the indication will be returned to the lever by the current generated by the motor instead of by battery current, as is required with a solenoid mechanism.

In this installation the use of detector bars is practically abolished, a few only being used on the outside rail on sharp curves. Short electric track circuits are provided in their place, effecting the locking of the switches during train movements by controlling the locks on the switch levers. The use of these short track circuits with the controlling wires to the interlocking machine makes possible, at small expense, the use in the interlocking tower of an illuminated track indicator consisting of a track plan of the interlocking painted on a piece of ground glass with the track circuit sections divided on the back of the glass into separate compartments in which are a red and a white electric light. When the track section is occupied a red light will be shown on the indicator plan, and when unoccupied a white light will be shown.

In places like the Grand Central terminal where the tracks will be entirely roofed over it will not be possible for the signal man to observe the movements of many of the trains and an indicator of this kind is an absolute necessity to enable him to keep in touch with the situation. As in the Park Ave. tunnel, the signals in the Grand Central Station interlocking will be shown entirely by lights, without any blades or moving parts. In this interlocking work, however, the lever for the signal completes the circuit for the lamps to give the proper color for the indication required.

THE TUNNEL UNDER THE ENGLISH CHANNEL.

The old project of a tunnel under the English channel to connect the railway systems of Great Britain and France, and some experimental work upon which was done at both ends several years ago, has been recently discussed by a French engineer, Mr. Albert Sartiaux, in view of the modern developments of electric power and the special methods of rapid tunneling adopted for the great Simplon tunnel, recently completed. From his review of the project in the "Revue Generale des Chemins de Fer," we take the following particulars. In 1875 a French company with $4,000,000 capital (headed by Rothschild Brothers) was granted a concession for a tunnel from some point near Calais and "directed towards" Great Britain. The concession was for 99 years, without subsidy or guarantee on the part of the government, but the government agreed not to grant a similar concession for 30 years. The company was to execute preliminary works at a cost of at least $40[illegible] state within five or eight years if it [illegible] to the concession. The company has [illegible] obligations, and has spent more tha[illegible] sum on shafts, headings, borings, tes[illegible] In 1883 it had one gallery 6,035 ft. [illegible] driven by hand drills but mainly by [illegible] mont compressed-air drills, which m[illegible] vance of about 5,420 ft. in 257 days [illegible] chine made a record of 1,312 ft. in [illegible] and could probably have reached [illegible] work had been continued. The diff[illegible] objections, according to Mr. Sartiaux [illegible] on the English side. A company wa[illegible] England in 1872, but has not been [illegible] cure a definite organization, and the [illegible] purchasing the necessary land w[illegible] granted to it by Act of Parliament in [illegible] been allowed to lapse. But while th[illegible] has ceased to have a definite exi[illegible] Southeastern Ry., of England, entered [illegible] munication with the French com[illegible] (adopting its views as to the geologi[illegible] tions) started preliminary works at a point between Folkestone and Dover in 188[illegible]. The results were as favorable as on the French side, but objections were raised by the British military authorities and work was ordered to be stopped; since then, in spite of various subsequent attempts, it has not been possible to overcome these objections.

From the geological investigations, the borings, and the outcroppings on both sides of the channel, it is confidently expected that the work can be carried in continuous beds of chalk, without faults or interruptions, while the beds are so thick, solid and impermeable as to afford very favorable conditions for tunneling. At the same time there are strata of unreliable material in the neighborhood, and the difficulty will be in the location rather than in the boring of the tunnel. It would probably be necessary to feel the way step by step by means of trial headings or borings. Instead of a direct line, therefore, the tunnel would probably be more or less curved, and in this respect the introduction of electric traction presents advantages in allowing easy operation of sharper curves and heavier grades than would be practicable for ordinary steam locomotives. With curves of 984 ft. to 1312 ft. radius and grades of 1.5 to 2% the tunnel could readily follow the irregular line of the bed of good material.

A double-track tunnel would be approximately oval in cross-section 30 to 33 ft. wide and 20 to 23 ft. high, and while a minimum thickness of 130 to 165 ft. of the impermeable chalk stratum is expected, it is considered that the safer plan would be to drive two parallel circular tunnels of 18 to 20 ft. diameter, 60 ft. c. to c., connected at intervals of 350 to 400 ft. by transverse galleries. Another point to be considered is whether the drainage should be provided for in the main tunnels or in a separate gallery. The former plan would necessitate a high elevation at the middle and a low elevation at each end, whereas economical construction and operation require a minimum elevation at the ends. The engineer, Mr. Breton, has adopted the latter plan, the gal-

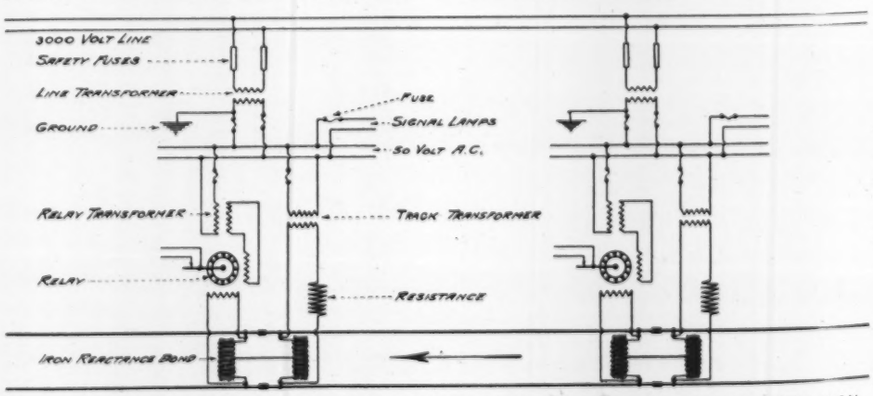


FIG. 4. TYPICAL ALTERNATING CURRENT TRACK CIRCUIT, TWO-RAIL RETURN WITH IRON CORE REACTANCE BONDS.

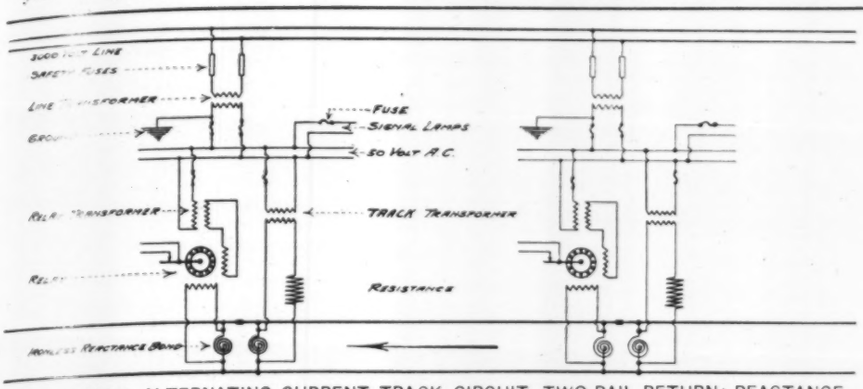


FIG. 5. TYPICAL ALTERNATING CURRENT TRACK CIRCUIT, TWO-RAIL RETURN: REACTANCE BONDS, WITHOUT IRON CORE.

lery being about 7 ft. diameter; it would connect with a sag in the grade line near the center of the tunnel, and then diverge horizontally and vertically, terminating in a pumping shaft at Calais. The proposed plan is to start the drainage tunnel first and to run lateral galleries to the line of the main tunnels, so that work on the latter can be driven from several headings, the excavated material being hauled away through the drainage gallery. The middle of the tunnel would be the summit of short grades from either side, and from the bottom of each grade the tunnel would then rise towards the shore. It is estimated that the drainage gallery and both tunnels could be completed in 4½ to 5 years of actual tunneling, after the construction of preliminary works, including the main shaft and means for handling the excavated material.

The total length of the tunnel would be about 30 miles, the width of the channel at the Straits of Dover being about 21 miles.

REPORTS OF THE NATIONAL BOARD OF FIRE UNDERWRITERS' COMMITTEE OF TWENTY.

A number of the excellent reports on the water supply and fire protection of cities issued by the Committee of Twenty of the National Board of Fire Underwriters* have been abstracted recently in these columns. We give below some interesting statements extracted from the last annual report of the committee and also from a pamphlet issued by the committee in explanation of the scope and object of its investigations.

In its report the committee states that there are now 116 subscribers in support of the work of the committee, of which 107 are "regular National Board members" and the nine others are special subscribers paying $500 a year. The regular subscribers are assessed on the premiums received by their respective companies. The assessment for the first year of the investigation was 1-15th of 1%, and for the second year 1-17th of 1%. The total expenditures for the first year of the investigation were $81,500, and for the second year $102,000. Of the latter sum, $46,956 was paid to engineers as salaries and $10,082 for officers' salaries. Reports on 46 cities have already been made in pamphlet form, and work in a dozen other cities is under way. The report contains detailed information as to the improvements to date carried out in accordance with the recommendations of the various reports. These have been summarized as to the expenditure by cities and show a total of nearly $5,000,000, of which nearly $2,000,000 has been laid out in Buffalo and nearly $1,000,000 in Rochester.

The second pamphlet, mentioned above, which is entitled "Analysis of Reports of the National Board of Fire Underwriters Committee of Twenty," takes up in order the various headings found in the report of the several cities. Explanations are given as to why information is sought and presented under these headings. As to fuel, it is said that knowledge on this subject is useful as a guide to the condition of flues and the deterioration of buildings, particularly as to the corrosion of tin roofs and iron-clad structures, and the effect upon certain stones, especially those with a carbonate matrix. High temperatures are not of great importance, "but low temperatures, especially if of long duration, mean a great deal," since they involve a large number of fires from heating apparatus, greater difficulties incurred in fighting fires, and an increase in the number of frozen hydrants and water mains. The paragraphs on Ownership and Consumption are well worth quoting in full, and with these our extracts will be concluded, as follows:

OWNERSHIP.—A careful consideration of the various factors entering into the problem of ownership leads to the belief that this topic cannot well be omitted. In works of private ownership we seldom find a contract or agreement of any kind stipulating in definite terms the quality of fire protection which shall be provided. Indeed, the question of supply for fire purposes involves so many elements widely different in character from those affecting domestic supply that it is difficult to draft a satisfactory binding agreement. The nature of the problem makes the returns on the investment larger and quicker in providing domestic service than in furnishing a good fire protection supply. The exploiting of the latter is not attractive to private capital. In other words, private owners of water-works are not apt to appreciate fully the fire protection side of water-works as they are dividends. New roofs on pumping stations, larger mains, increased pressures, etc., eat into profits. And strictly speaking, they may not be necessary from the standpoint of private ownership. A water system, very poor from a fire protection viewpoint, might be, and often is, a profitable investment to its owners.

Again, the service rendered by public and quasi-public corporations, including the domestic supply of private water companies, is affected favorably by the public's every-day contact. The available supply for fire purposes, however, is a reserve called into action but seldom; and, when its deficiencies are manifested, they do not come directly to the attention of the people. It is only when ineffectiveness is followed by disaster that the public becomes thoroughly alive to the situation and brings its power to bear on a private company. And then the horse is stolen. On the other hand, the management of municipal works is accountable to the people and under the spur of a direct responsibility for the condition of a system and its ability to deliver water for fire protection as well as for other purposes. A municipality owned and operated works, therefore, may be expected to meet more nearly fire protection requirements than one of private ownership.

CONSUMPTION.—Consumption and water waste frequently contain the key to a costly and otherwise undesirable situation. The elimination of waste by the introduction of meters and proper restrictive measures has often postponed for years costly extensions, enabling a municipality to undertake other needed reforms. Failure to do so has, on the other hand, frequently resulted in expensive additions to pumping stations, larger supply mains, increased reservoir capacity, etc. The city of Buffalo has an average daily consumption at least four times as large as it should be. The result is that pressures and immediate supply at any one point are generally too low, and costly additional pumping machinery has been necessary. The citizens argue that the supply is unlimited, and further, that the water-works is self-supporting, forgetting that they are supporting it. If they had to pay the same increased tax in the form of insurance rates, a hue and cry would be raised immediately. Information as to the consumption is also directly interesting in establishing the margin of reserve for fire purposes.

*S. H. Lockett, Secretary to the Committee, 135 William St., New York City.

SOME NOTES ON THE LOS ANGELES OUTFALL SEWER.

By W. P. Hardesty,* C. E.

The city of Los Angeles, Cal., has at present an estimated population of about 200,000. The Pacific Ocean is less than 15 miles distant from the center of the city.

OLD SEWER.—In 1894 an outfall sewer was completed, leading from near the southwest corner of the city southwesterly to a point on the ocean beach between Redondo Beach and Santa Monica. It consists of 4⅓ miles of circular brick conduit, mostly 40 ins. diameter; 1¼ miles of 6-ft. tunnel, and two inverted siphons, each about 3.4 miles long, one of 36-in. and one of 38-in. wood stave pipe. The total cost was $370,000. [See Eng. News, Feb. 28, 1895, for plan, profile, and other illustrations, and full descriptive text, with cost figures, and Feb. 10, 1898, for notes on the operation of the outfall.]

After a few years' use the interior of the brick conduit and the tunnel (of brick and concrete) were showing disintegration. Mr. Rudolph Hering, M. Am. Soc. C. E., was engaged to examine the structure. He diagnosed the case as one where the ventilation of the sewer was entirely insufficient, resulting in the generation of gases

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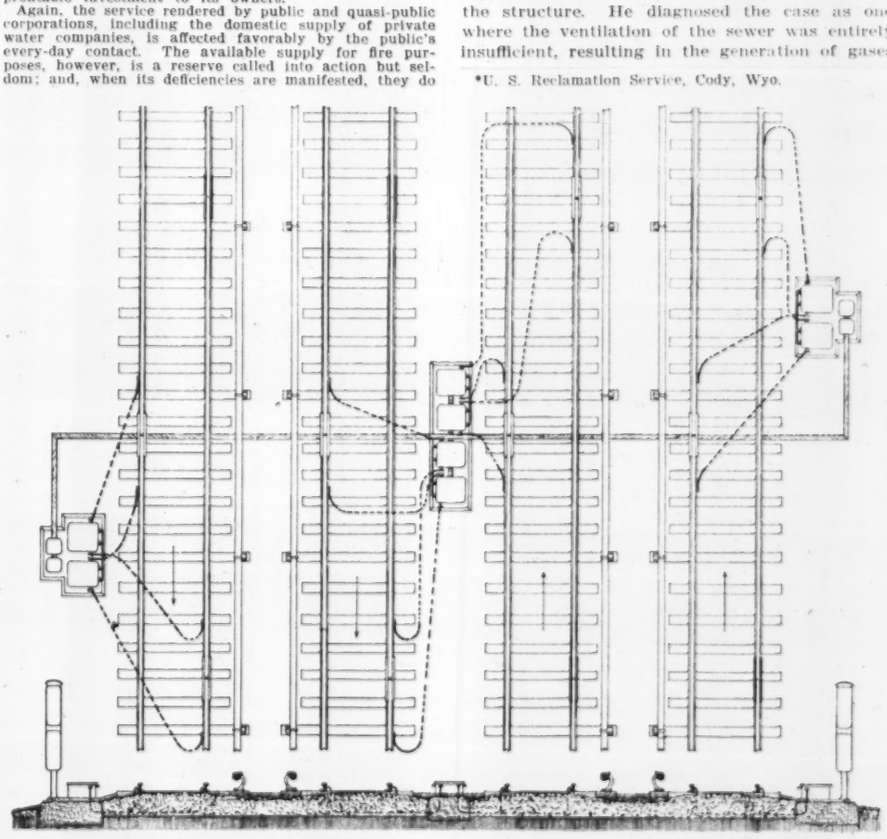

FIG. 7. PROPOSED ARRANGEMENT OF REACTANCE BONDS, SHOWING FOUR-TRACK LOCATION OF BONDS AND CONNECTION TO RAILS.

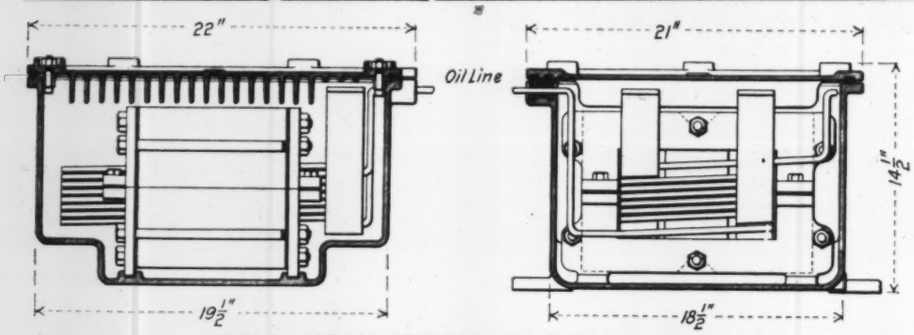

FIG. 6. DETAILS OF REACTANCE BOND AND CASE.

that attacked both the cement mortar and the bricks. The former was crumbling into a powder and the latter were spawling off, the disintegration of the mortar extending into the joints in places as much as one-half in. [See Eng. News, Nov. 8, 1900, for report on examination of outfall sewer.] The first deterioration was found after the sewage had passed the first siphon, where a strong odor also became manifest. The strongest odor was noticed several miles farther on, and especially at the first drop in the sewer, by which the gases in the sewage were freely liberated. The deterioration at this point, also, was the greatest. Below the surface of the flowing sewage the bricks and mortar were found to be perfectly sound.

When passing through the long inverted siphons there was no air or oxygen available for oxidation, and the process of decomposition was chiefly one of putrefaction. On emerging from the siphons into the conduit the sewage again came in contact with the air, and the escaping gases were concluded to be the undoubted cause of the trouble.

From the foregoing it would appear that inverted siphons, especially when of some length, are very objectionable features in a sewerage system, as ventilation is impossible in them. In this particular case the rather low velocity in the siphons greatly aggravated matters, as it gave more time for the putrefying process. Another cause of the generation of the gases is found in the mild and nearly uniform climate at Los Angeles, on account of which the difference in temperature between the interior of the sewers and the air outside is comparatively small, so that there is little tendency to create a draft of air through the sewers, which is necessary for a good ventilation.

NEW SEWER.—On account of the trouble experienced with disintegration, and also from the formation of deposits along the flatter gradients, and also because of the rapid growth of the city, it was decided to build an entirely new sewer. Bonds for this were issued in 1902-3, and work was begun in 1904.

The new system follows a somewhat more direct route than the old one. It has a down grade all the way, varying from 1 in 200 to 1 in 1,100, necessitating much heavier work in trenching and grading, and also a longer tunnel, than in the old sewer. It is estimated that the time of passage of sewage will be reduced from 24 hours to only 4 hours, and the liability of deposits will also be greatly diminished. The sewer begins at Jefferson St. and Wesley Ave. (in the southwest part of the city), and has a length of 65,000 ft. It consists of a brick conduit throughout. About ten different cross sections are used for the various conditions encountered along the line.

For the first 2¼ miles, where the grade ranges from 1 in 200 to 1 in 500, the conduit is circular, ranging from 44 ins. to 49 ins. For 8 miles beyond this is a uniform grade of 1 in 1,100, on which slight variations of an elliptical section, averaging about 5 x 6 ft., are used. Nearer the ocean there is another long stretch of circular conduit (57-in.), where the grade is 1 in 500.

In ordinary situations the conduit has only two rings of brick. Where in made ground, or in that where the top of the sewer is but little below the natural surface, and also in the tunnel, three rings are used. At these points, where crossing depressions several feet below grade, a concrete cradle 10 ft. wide on the base is used for support of the brick section.

The interior of all sections is plastered with ½-in. cement plaster up to one-half the height. The extrados of the arch is covered with ½-in. of cement mortar. It is intended that the sewer shall run only half full, and its capacity at that level is calculated at 50 sec. ft., or over 32,000,000 gals. per day. This will afford an abundant air space above the flowing sewage, allowing rapid oxidation. Connection with the outside air is afforded by manholes at average intervals of about 500 ft. for all except the tunnel portion. Both of these features are decided improvements over the old sewer.

Beginning at 4.6 miles from the head is the main tunnel, a trifle over two miles long, and in which the sewer invert is 25 to 85 ft. below the ground surface. There are ten ventilator shafts along the tunnel, spaced at intervals of about 1,000 ft. Each consists of a well casing of 15-in. steel pipe (sunk before beginning the tunnel work), in which a lining of 12-in. sewer pipe was placed. The latter was lowered into the steel pipe from the ground above, the successive lengths being added as it descended. Special joints were used for this sewer pipe.

Below the lower end of the tunnel there is a stretch of about 7,000 ft., in which the natural surface of the ground is mostly below the top of the conduit, in places even several feet below its bottom. A large amount of filling [illegible] therefore necessary to provide the minimum [illegible]ering of 3 ft. of earth over the top of the [illegible]er. The filling is brought up in 9-in. layers, [illegible] the side slopes are 2 to 1. To thoroughly [illegible] some of the higher fills before building the [illegible] a small embankment was raised around the [illegible] edge to form a shallow basin, into which [illegible]ater was pumped and kept in it for several [illegible]s.

At the end of the 8-mile section [illegible] spoken of the line of the new sewer [illegible] that of the old one, and follows it to the [illegible]. Where in ordinary trench excavation, the [illegible] sewer is being torn out and rebuilt, largely [illegible] new material. In two tunnels, one of 900 [illegible] and one of 1,300 ft. length, the old sewer will [illegible] used, but the brick work is being well cleaned, each joint dug out to hard mortar and any loose brick removed, after which a ½-in. coat of cement plaster is applied to the entire surface. While this is being done the sewage is diverted into fields, where it is used for broad irrigation. As the old tunnels have an oval section 6 ft. high, their capacity is sufficient for the needs of the new system without enlargement. On a short strip of open trench work between them the same 6-ft. oval section is used for the new work. At the end of the second tunnel the conduit connects with a 24-in. cast iron pipe. This is at the edge of the bluff overlooking the ocean, and the pipe drops 50 ft. on a steep gradient. Here it joins a 30-in. riveted steel pipe, which extends on a pile pier about 1,000 ft. out into the ocean, where its outer end is about 2 ft. below mean tide.

The city owns a strip of ground extending along the coast about one-half mile on either side of the outfall, and the solid materials are so well comminuted and carried out by the tides that no accumulations occur on the shores of adjoining lands.

At the head of the 24-in. cast iron pipe before spoken of is a concrete tank, in which the floating materials are separated from the sewage, so as not to be discharged into the ocean. This is done by compelling the sewage to pass through openings near the bottom of a series of baffle boards. The lighter materials are thus afforded an opportunity to rise to the surface, from which

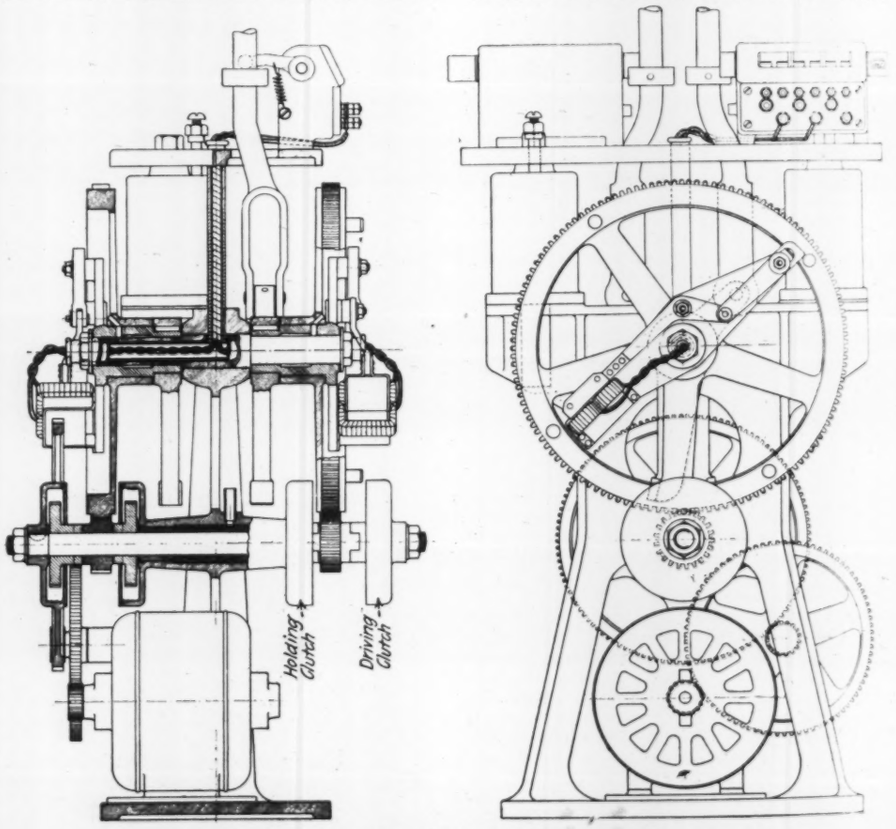

FIG. 8. DETAILS OF BLOCK SIGNAL MECHANISM.

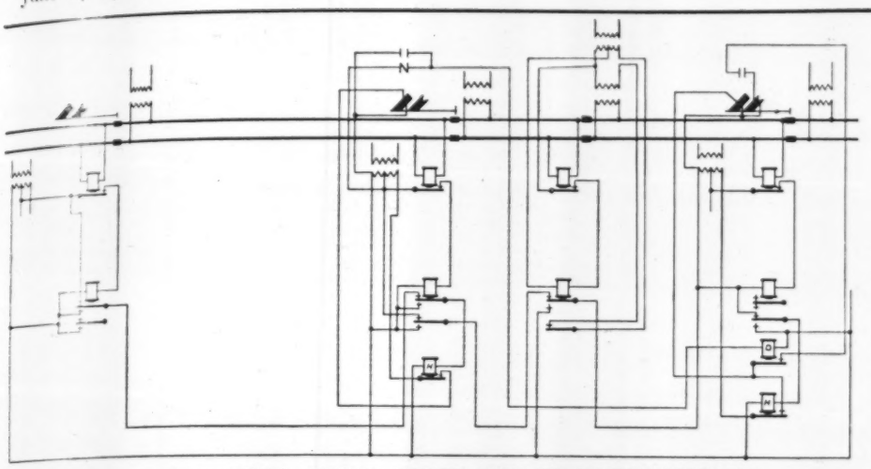

FIG. 9. TYPICAL SIGNAL CIRCUIT, POWER SUPPLIED BY TRANSFORMERS.

they can be raked off. Heavy materials are deposited on the bottom of the tank, which may be cleaned when out of service by use of a by-pass for the sewage.

A considerable source of profit to the city is supplied by the sale of the sewage for broad irrigation. In this climate, where crops are grown at all seasons, the sewage is valuable all the year except during the rainy season.

The work is being built by contract, but the city furnishes the cement and brick. The estimated cost as planned at the beginning was as follows:

Contract work	$565,000
17,000,000 brick (hard burned), at $8 per M....	136,000
39,000 bbls. Portland cement, at $2.00 per bbl..	78,000
Total	$779,000

The prices for brick and cement include their delivery on the ground.

The system was designed under the supervision of Mr. Harry F. Stafford, the present City Engineer of Los Angeles, and the construction is being carried out under his general charge. The work is now well along towards completion.

ALLOWABLE UNIT LOADS ON KNIFE EDGES FOR TESTING MACHINES AND HEAVY WEIGHING SCALES.

By Jos. W. Bramwell.*

It has been the writer's privilege for several years to study the manufacture of the weighing mechanism of testing machinery having knife edge supports for its levers.

Allowable loads on knife edges vary with the manner the pivots or knife edges are held in the lever and the pivot supports or seats secured to the base of weighing machines.

The writer is inclined to believe, from personal observation, that very little care is exercised in most heavy weighing scales as to proportion of length of the pivot or the method employed in securing the pivot to its lever. Frequently the writer has seen slender pivots overhung from the side of the lever, and by figuring the deflection from a moderate load found, as in many overhung journal bearings, that the extension of the pivot beyond the solid support was practically worthless. The case of the pivot is much worse than the shaft, because the local distortion is greater; hence the pivot would touch its support only over a fraction of its length.

In testing machinery, however, greater care is generally given to these details, although serious faults are still prevalent with some machines considered standard.

The testing machine is nothing but a weighing scale having a straining mechanism which pulls upon a specimen; the resistance of this specimen is weighed precisely as upon a platform scale.

A defective but cheap practice in fitting pivots to levers of testing machines, particularly those designed to carry a heavy load, and those upon which the weigh table of the machine rests, is to cast the pivots in the body of the lever, using square tool-steel pivots for cores. These pivots have a certain taper, which allows them to be driven out when the casting is cool. In spite of the care used in placing these cores in the mold, their correct positions will be changed after the casting is poured. To bring them into proper alinement again, considerable skill and care is necessary.

The greater fault of such practice, however, is in the shape of the hole in the casting. The hole being square and its diagonal necessarily vertical, a very bad breaking point is made by the sharp corner; the tendency to break is also increased by the chilled iron immediately in contact with the pivot, and the initial strain due to driving the taper pivot in, still further reduces the strength of the lever at this point. The hole is frequently enlarged by the wedge action of the pivot under load; and on account of the irregular surface at the upper sides of the pivot, the pivot will assume another position and change what should be a fixed ratio—the lever lengths. I have purposely dwelt upon these irregularities in construction to show why allowable loads are variable.

Loads of 10,000 lbs. per inch of length on knife edges are permissible, but the pivot must be flat at its upper portion, normal to the load and supported its whole length, with a minimum deflection of parts to ensure reasonable accuracy.

The quality of steel used in pivots and seats has an important bearing upon the allowable load. In all cases it is essential that a high-grade uniform tool steel be used, having a carbon content of 0.90% to 1.00%. Such steel will take a very high temper and yet have sufficient ductility to resist sharp blows without crumbling. The temper of the seats should be drawn to a very light straw color; that of the pivots should be *slightly* darker. For accurate results it is very desirable to know the heat which must be used to produce the proper hardness. Reliable steel makers grade their steels for carbon content and give full information for heat treatment.

The angle of 90° for the knife-edge has given good results for heavy loads. For ordinary weighing machinery and most testing machinery 5,000 lbs. per inch of length will be found an ample allowance. In a recent testing machine of 800,000 lbs. capacity, made from the writer's designs, the two large levers had a load of 10,000 lbs. per inch on the pivots for the maximum load. Each pivot had an effective length of 40 ins.

The edge may be made perfectly sharp, for loads up to 1,000 lbs. per inch of length. For greater loads the sharp edge is rubbed with an oilstone, so that a smoothness is just visible. A pronounced radius of knife-edge will decrease the sensibility of the apparatus. The seat, if an angular one, is shaped with a small radius at the intersection of the sides of the angle.

*1125 Real Estate Trust Bldg., Philadelphia.

BRAKE BEAMS FOR 60,000, 80,000 AND 100,000-LB. FREIGHT CARS.*

Recognizing that the present standard requirements (adopted in 1889) for freight brake beams are inadequate for existing conditions of service, and that a very large percentage of the brake beams now used do not even approximate the M. C. B. specifications, this association last year appointed your committee to investigate the subject and submit specifications and tests for brake beams for 60,000, 80,000 and 100,000-lb. capacity cars. Your committee found it necessary:

(1) To determine the strength of the beams now on the market and ascertain their adaptability to the service required, which necessitated an investigation and test of the various means which are now generally used. This investigation was undertaken for your committee by Purdue University as represented by Dean Goss, and was directed by Dr. W. K. Hatt, Professor of Applied Mechanics. Dr. Hatt was assisted by H. H. Scofield, Instructor of Applied Mechanics.

(2) The duty of determining the proper location and dimensions of brake beams, to enable the committee to prepare specifications for beams of proper strengths, was delegated to a sub-committee, composed of Mr. R. B. Kendig, Mechanical Engineer of the L. S. & M. S. Ry., and a member of our committee, Mr. J. G. Platt, Engineer of Tests, Erie R. R., and Mr. L. L. Bentley and his successor, Mr. J. N. Mowery, Mechanical Engineer, Lehigh Valley R. R. Co.

In order to carry out the tests at Purdue University,

*Report of Committee of Master Car Builders' Association presented at the annual convention at Atlantic City, N. J., June 13, 14 and 15, 1906.

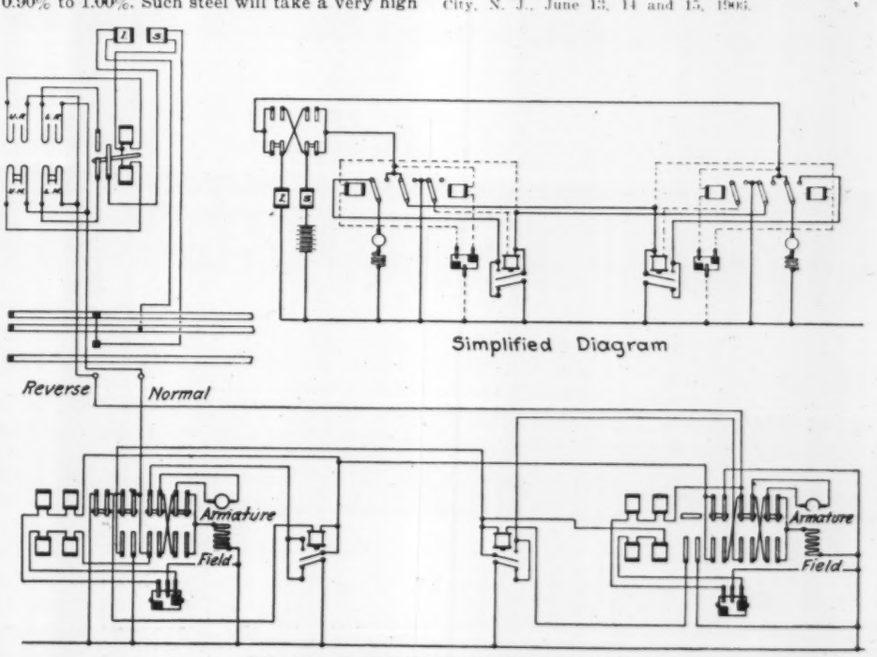

FIG. 12. DIAGRAM OF SWITCH CIRCUIT.

several beams of the various makes were taken from regular stock and donated to the committee by the following companies: Pennsylvania R. R., Erie R. R., L. S. & M. S. Ry., Lehigh Valley R. R., Armour Car Lines, Pressed Steel Car Co., Buffalo Brake Beam Co., Chicago Ry. Equipment Co., Gilbert P. Ritter.

PRESENT CONDITIONS.—A general review of the brake beam situation disclosed a deplorable state of affairs. It may seem a startling statement, but it is nevertheless true, that in many directions less attention is now being given to brake beams (the vital part of the foundation brake rigging) than 12 or 14 years ago, notwithstanding markedly changed conditions, as well as greatly increased requirements of service. It also appears that in some cases any "metal brake beam" is interpreted as an acceptable beam.

PAST AND PRESENT REQUIREMENTS.—The present standard M. C. B. requirements for brake beams were adopted in 1889, and were the result of a thorough investigation and a series of tests made by the committee appointed to report on "Standard Brake Gear for Air Brake Cars, with Brake Shoes, for Iron Beams." That committee considered the subject carefully, and while it was the original view of the committee that the standard for freight service should be 15,000 lbs., with only 1-16-in. deflection, the result of their extensive tests showed that manufacturers had not then reached the point of making an economical and satisfactory beam to meet this requirement for freight service. That committee therefore recommended that the association adopt two brake beams:

"No. 1, to stand a load of 7,500 lbs., with maximum deflection of 1-16-in."
"No. 2, to stand a load of 15,000 lbs., with maximum deflection of 1-16-in."

That committee also reported:

"Beam No. 1 is intended for all freight cars now constructed, and beam No. 2 for passenger cars and freight cars, in the event of the adoption of a larger cylinder, or the introduction of a device for graduating automatically the braking power in proportion to loads and speed."

It will thus be seen that in 1889 the 7,500-lb. requirement was considered a minimum, and the suggestion was then made for just such a condition as now exists. The maximum capacity of cars then being built was 60,000 lbs., though but comparatively few of that capacity were then in service, and the 8-in. air-brake cylinder was the largest size then in use on freight cars. The weight of cars then in service ranged from 18,000 lbs. to a maximum of 33,000 or 34,000 lbs., and this maximum was exceptional except for heavy refrigerator cars. It is safe to say that a fair average for the majority of cars then in use was not over 25,000 lbs. At that time the percentage of braking power to the light weight of the car did not exceed 70%. Therefore, the maximum load applied to the average car did not exceed 4,500 lbs. per beam, and the maximum load for the heaviest car did not exceed 6,000 lbs. per beam.

At that time the use of the air-brake was in its infancy, and brake beams were not generally subjected to the present severe conditions of air-brake service. The speed and weight of trains were then very much less than in recent years, and no federal law governing the percentage of cars per train on which brakes must be operative. To-day we have extensively in use cars of 110,000 lbs. capacity. The minimum weight of cars now in use may safely be said to be 24,000 lbs., while the maximum weight runs as high as 55,000 lbs., and a fair average may probably be stated as between 42,000 and 45,000 lbs. On the same basis of 70% of the light weight of car, the average braking requirements would be raised from 4,500 lbs. to 7,800 lbs. or more per beam. Under present conditions, the braking power can be, and in many cases is, increased to 85 and 90% of the light weight of the cars, which gives a load of from 9,000 to 10,000 lbs. or more per beam.

INEFFICIENT BRAKE BEAMS.—Notwithstanding the increased requirements of to-day due to both the weight of cars and speed of trains, and the fact that the present M. C. B. standard beams are not sufficiently strong for the service, a very large number of brake beams now being used do not even meet the specifications of 1889. The result is that such brake beams not only give inefficient service but soon fail.

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Many roads are still applying "outside hung" brake beams, which we believe is radically wrong, as it is impossible to obtain satisfactory results with beams so hung. Outside hung beams are affected by the action of the bolster springs, curving of the trucks, sagging of the car body, etc., all of which prevents effective braking, and particularly under the varying conditions of loaded and empty cars. There is no argument in favor of such an arrangement, with the one exception, that they are more accessible.

A brake beam should be hung inside of the wheels to some rigid portion of the truck, so that it will always maintain the same relative position to the wheels; when so hung the beams are easier to maintain, and not being exposed are less liable to be struck by obstructions on the track (impromptu bumping posts, etc.). The first cost of the inside hung brake beam is less, they cost less to apply, and most important of all, give more effective results in braking.

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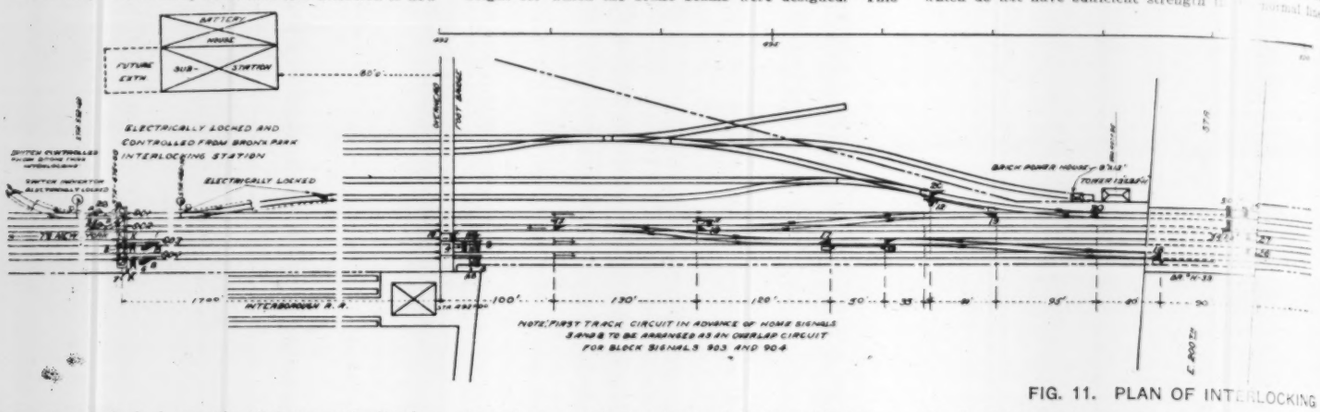
ELECTRICALLY LOCKED AND CONTROLLED FROM BRONX PARK INTERLOCKING STATION
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FIG. 11. PLAN OF INTERLOCKING

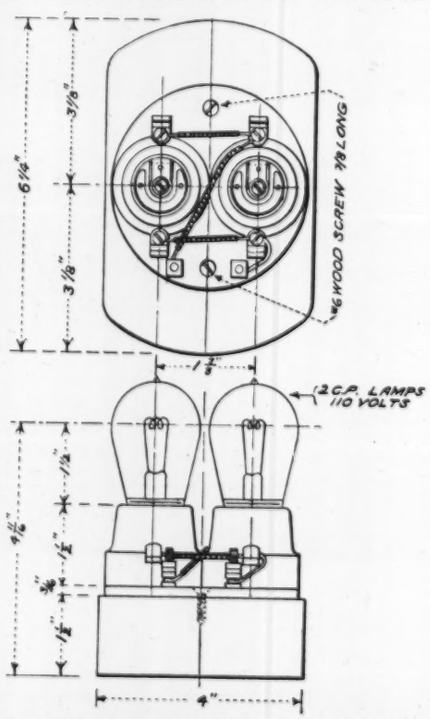


Fig. 10. Electric Light Attachment for Signal Lamp.

of pull. Being overloaded they fail and ... line of least resistance, this being "transversely" or up and down in relation to the position of the beam on the car.

SPECIFICATIONS AND TEST...

The fundamental object in using a metal brake beam is to insure the efficiency of the air-brake by setting a minimum deflection, and consequent minimum piston travel at the required load, and to accomplish this with a structure of the required strength and stiffness at a minimum weight and reasonable cost.

CAPACITY.—In arriving at the desired working capacity we may assume 50,000 lbs. as the maximum weight of line or general service freight cars; there may be some instances of special construction where this weight is slightly exceeded, but these exceptions need not be considered in view of the allowance to be made later. Now, assuming 1,500 lbs. unbraked weight per axle as a minimum which can be allowed to avoid skid flat wheels and we will have a maximum braking power of 50,000 lbs., less 6,000 lbs. or 44,000 lbs.; this divided by four gives a maximum braking force of 11,000 lbs. per beam. Adding to this value a reasonable factor of safety necessitates a capacity in the brake beams of 15,000 lbs.

DEFLECTION.—In establishing the proper capacity of beams it will be noted that the present M. C. B. allowable deflection of 1-16-in. has been used, it not only being the recognized standard by which to measure all capacities of brake beams, but experience has shown that this can be easily met in economical design, and it also leaves sufficient elasticity to withstand the shocks of service without injury or permanent set. We believe that the above capacity of brake beams for heavy freight cars is sufficient for present conditions, and provides for any possible increase in the future requirements. This would really be a readoption of the present standard, for by reference to the report of the 1889 committee, it will be seen that the No. 2 brake beam, 15,000 lbs., with 1-16-in. deflection, is really the present standard "where a larger cylinder is used, or a greater capacity than 7,500 lbs. is required."

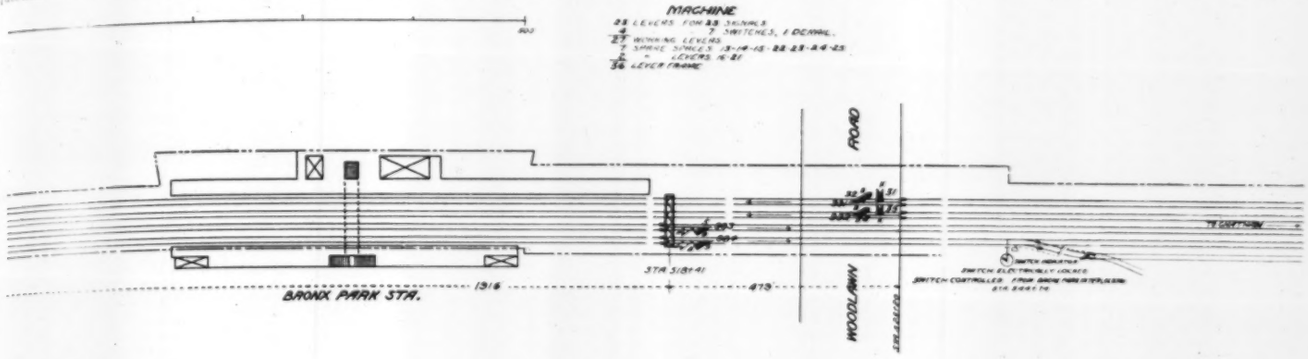
LENGTH OF BRAKE BEAMS.—As a result of the recommendation of the Air Brake Association to change the present standard length of brake beams and the action of the Master Car Builders' Association in submitting the question to letter ballot, a difference of opinion has arisen, and we are informed by the manufacturers that they are now called upon to furnish three different lengths of brake beams, namely: 60 ins., 60¼ ins. and 60½ ins. of brake shoes. This, with allowable and unavoidable variations of ¼-in. in manufacturing, gives the extremes in length of 59¾ ins. and 60¾ ins. Your committee should therefore decide upon, and recommend for adoption as standard, some definite length of brake beam from center to center of brake heads, together with limits of variation, which will be allowable.

The recommendation of the Air Brake Association to shorten the length of brake beams was for the purpose of obtaining greater efficiency by insuring the bearing of the full width of the brake shoe on the tread of the wheel, thereby obtaining a greater amount of friction and wearing value; inspection having shown that a large number of old brake shoes were flanged or only partially worn from overlapping the treads of the wheels. This is a condition of service which can and should be remedied. It is due to the excessive length of some brake beams, and the improper hanging of others.

We would recommend that the Association specify that all brake beams should be 60¼ ins. from center to center

face of the brake heads with an allowable variation of not over ⅛ in. either way from this.

BRAKE HEADS.—A great deal of difficulty has been experienced in fitting the brake shoes on many of the brake heads now on the market, due to the brake heads not conforming to the M. C. B. dimensions, either from fault of drawings or patterns, or the distortion of the castings in the process of annealing and manufacture. It would therefore seem important that we consider this question with a view of having all brake heads made



SIGNALS AT BRONX PARK.

strictly in accordance with the present M. C. B. contours or dimensions, to insure more satisfactory service and avoid the difficulties which have been experienced in the fitting of the brake shoes.

Many brake heads are found which bear at the ends and lack contact at the center, causing the shoes to break at the center when worn. Many brake heads also will not allow the brake shoe to be properly driven into place.

It is important that all brake heads be of such an angle in relation to the center line of the fulcrum, or the normal line of applied force (which is horizontal) that the shoes shall be in perfect contact with the tread of the wheels when applied.

LEVER FULCRUMS.—The power being applied to the brake at the fulcrum it is important that we give some consideration to this detail. The present M. C. B. standard angle of 40° from the vertical for the lever slot is now almost universally used on freight brake beams and should be maintained as a standard.

The present M. C. B. standard lever pin which is 13/32-in. in diameter is also generally used and should be maintained, having ample shearing and bearing value for a brake beam of the increased capacity previously recommended, but the diameter of the lever pinhole in the brake beam fulcrum should have our attention. Inspection has shown that the standard of 1⅛ ins. in diameter in many instances is not being adhered to. Many brake beams have pinholes roughly cored, and both too large in diameter and out of round, many being found 13-16-in. to 1¼ ins. in diameter. It is very important that these pinholes do not exceed 1⅛ ins. in diameter, so as to eliminate lost motion as well as to reduce the wear at this point. The tendency to wear increases very rapidly in proportion to the amount of play. In the case of malleable iron fulcrums these holes should be drifted (not drilled) to size. The advantage of drifting the holes in a malleable casting is that they are trued and forced to size without removing the skin or the best wearing part of the material; this process is not only better than drilling, but would also be cheaper for the manufacturer. In the case of wrought iron or steel fulcrums, these holes should be drilled or punched and reamed to size.

APPLICATION.—A proper and efficient brake beam having been determined upon, the next question which naturally arises is that of proper application. While some roads are still applying outside hung beams, the advantage of applying them to the inside of the wheels has been so generally recognized that the number of outside hung beams is now a very small proportion on modern equipment.

As the best results can only be obtained when beams are inside hung, we recommend to the Association that all brake beams be inside hung, and that the present M. C. B. standard height of 13 ins. from top of rail to the center of the face of brake shoes be adhered to on all new equipment. When this height cannot be obtained on old equipment, it is recommended that the beams be hung as high as possible; if provided with rigid heads they should be designed to suit the height at which they are hung. In all cases the lever fulcrum and the center line of the brake beam should be horizontal, which is in line with the applied power. In addition to the above we recommend that this Association adopt as recommended practice the following features of application as shown on Fig. 1, namely:

All brake hangers should preferably be attached to the brake head at the center of same, just back of the central brake shoe lug, so that they will be firmly locked in position by the brake shoe, and by bringing them as close to the shoes as possible, overcoming the tendency of the beam to rotate about the hangers. This will also admit of the use of longer brake hangers, than if they were attached to the brake heads at a point above the center of same, and which is a desirable feature.

Where by reason of design of brake beam the recommended location of brake hanger eye is impracticable an alternate location 2½ ins. above the preferred location for brake hanger eye as shown by Fig. A, page 656, is permissible.

The slot for the brake hanger should be limited in dimensions as much as possible, in order to prevent wear and overcome the chattering or excessive movement of the beams up and down with the rotation of the wheels. In order to obtain a minimum play at this point of attachment, a standard size hanger ⅞ in. diameter should be adopted, and this size is now in general use.

In order that the proper release of the brake beam be obtained by gravity, the brake hangers should have an angle as nearly as possible to 90° from a line drawn from the center of the brake shoe to the center of the axle when the shoes are half worn. This will also prevent any possible wedging of the beams.

Third suspension hangers should be used on all brake beams when practicable to prevent the shoes from dragging on the wheels when the brakes are released. They should be attached to flexible (not rigid) brackets, and should have the same exact angle and length as the brake hangers to prevent binding or tilting of the beam.

Chains are preferable to safety hangers, as the yoke and similar forms of safety attachment are often so arranged that they strike the beams, causing a loss of power and a tendency to damage the beam; 51 ins. c. to c. of safety hangers is now generally used and should be adopted as standard.

FACILITIES FOR TESTING BRAKE BEAMS.—In order to insure the purchasers obtaining brake beams which meet these specifications, if adopted as standard, some provision should be made for testing the beams. Very few, if any of the railroads now have the proper facilities for doing this work.

SUMMARY.—Your committee accordingly recommends for adoption as standard, two brake beams, which shall be known as beam No. 1, for use under cars, having a light weight of 30,000 lbs. or less, and beam No. 2, which shall be used under cars, having a light weight in excess of 30,000 lbs. Both beams shall conform to the following specifications:

1. All beams shall be 60¼ ins. in length from center to center of brake head, with an allowable variation of ⅛ in. in each direction, and shall be proven by the gage shown by Fig. 3, applied to the center and each end of the brake heads, which shall be the standard gage for this purpose.

2. All brake heads shall conform to the M. C. B. standard dimensions, and shall be proven by a standard gage.

3. Attachments for safety hangers shall be 51 ins. from center to center.

4. The angle of the lever fulcrum shall be 40° from the vertical.

5. The lever pinhole shall be 3 ins. in front of the top of the brake head lugs. The variation in either direction shall not exceed 1/16 in.

6. The lever pinhole shall not be less than 1 3/32 ins. in diameter, nor more than 1 5/32 ins. in diameter, and shall be proven by the gage shown by Fig. 6, which shall be the standard gage for this purpose.

7. The maximum distance from the lever pinhole to the extreme back of brake beam should not exceed 9½ ins.

8. For each 500 brake beams, or less, which pass inspection and are ready for shipment, one representative beam shall be taken at random, and subjected by the company manufacturing the beams, and in the presence of the railroad company's inspector, to the following test in a suitable machine:

The beams shall be equipped with suitable heads and shoes, and the shoes placed in contact with castings representing the tread of the wheel; when mounted in this manner, the load shall be applied to the fulcrum in the normal line of pull. As a preliminary to the test a load of 6,000 lbs. shall be applied and released, after which observations for records shall be taken. Beam No. 1, under a load of 7,500 lbs., shall not deflect to exceed .0625 in.; beam No. 2, under a load of 15,000 lbs., shall not deflect to exceed .0625 in.

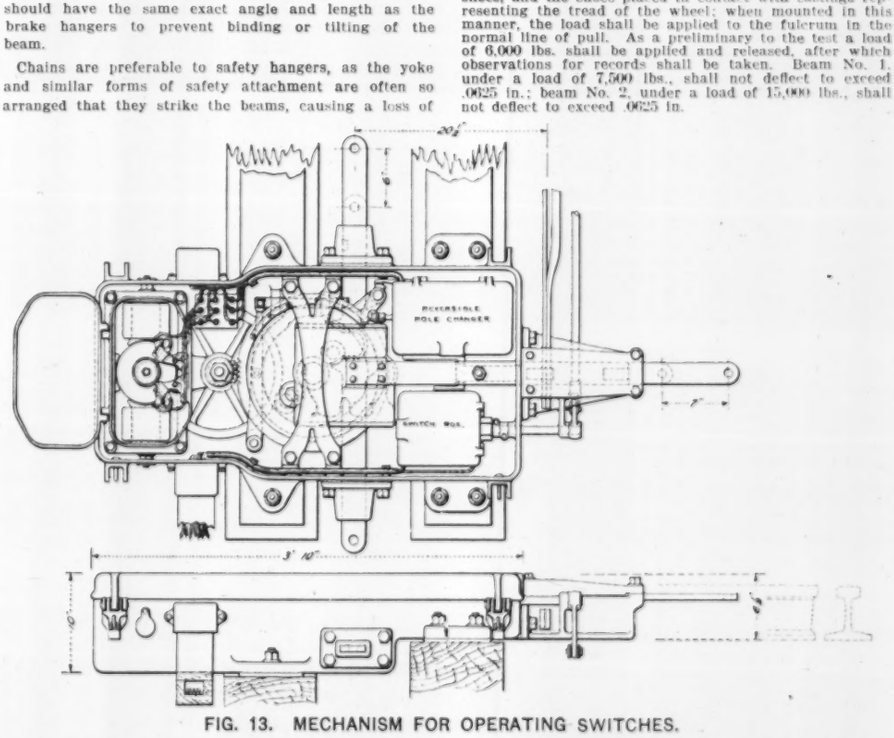


FIG. 13. MECHANISM FOR OPERATING SWITCHES.

9. In case a beam shall fail in this test, then a second beam shall be taken from the same lot and similarly tested. If the second beam stands the test, it shall be optional with the inspector whether he shall test a third beam or not. If he does not do so, or if he does, and the third beam stands the test, the 500 beams, or less, shall be accepted as filling the requirements of this test.

10. Individual beams will not be accepted which (1) do not conform to standard dimensions, and (2) that has physical defects. Any lot of 500 beams, or less, sub-

several beams of the various makes were taken from regular stock and donated to the committee by the following companies: Pennsylvania R. R., Erie R. R., L. S. & M. S. Ry., Lehigh Valley R. R., Armour Car Lines, Pressed Steel Car Co., Buffalo Brake Beam Co., Chicago Ry. Equipment Co., Gilbert P. Ritter.

PRESENT CONDITIONS.—A general review of the brake beam situation disclosed a deplorable state of affairs. It may seem a startling statement, but it is nevertheless true, that in many directions less attention is now being given to brake beams (the vital part of the foundation brake rigging) than 12 or 14 years ago, notwithstanding markedly changed conditions, as well as greatly increased requirements of service. It also appears that in some cases any "metal brake beam" is interpreted as an acceptable beam.

PAST AND PRESENT REQUIREMENTS.—The present standard M. C. B. requirements for brake beams were adopted in 1889, and were the result of a thorough investigation and a series of tests made by the committee appointed to report on "Standard Brake Gear for Air Brake Cars, with Brake Shoes, for Iron Beams." That committee considered the subject carefully, and while it was the original view of the committee that the standard for freight service should be 15,000 lbs., with only 1-16-in. deflection, the result of their extensive tests showed that manufacturers had not then reached the point of making an economical and satisfactory beam to meet this requirement for freight service. That committee therefore recommended that the association adopt two brake beams:

"No. 1, to stand a load of 7,500 lbs., with maximum deflection of 1-16-in."
"No. 2, to stand a load of 15,000 lbs., with maximum deflection of 1-16-in."

That committee also reported:

"Beam No. 1 is intended for all freight cars now constructed, and beam No. 2 for passenger cars and freight cars, in the event of the adoption of a larger cylinder, or the introduction of a device for graduating automatically the braking power in proportion to loads and speed."

It will thus be seen that in 1889 the 7,500-lb. requirement was considered a minimum, and the suggestion was then made for just such a condition as now exists. The maximum capacity of cars then being built was 60,000 lbs., though but comparatively few of that capacity were then in service, and the 8-in. air-brake cylinder was the largest size then in use on freight cars. The weight of cars then in service ranged from 18,000 lbs. to a maximum of 33,000 or 34,000 lbs., and this maximum was exceptional except for heavy refrigerator cars. It is safe to say that a fair average for the majority of cars then in use was not over 25,000 lbs. At that time the percentage of braking power to the light weight of the car did not exceed 70%. Therefore, the maximum load applied to the average car did not exceed 4,500 lbs. per beam, and the maximum load for the heaviest car did not exceed 6,000 lbs. per beam.

At that time the use of the air-brake was in its infancy, and brake beams were not generally subjected to the present severe conditions of air-brake service. The speed and weight of trains were then very much less than in recent years, and no federal law governing the percentage of cars per train on which brakes must be operative. To-day we have extensively in use cars of 110,000 lbs. capacity. The minimum weight of cars now in use may safely be said to be 24,000 lbs., while the maximum weight runs as high as 55,000 lbs., and a fair average may probably be stated as between 42,000 and 45,000 lbs. On the same basis of 70% of the light weight of car, the average braking requirements would be raised from 4,500 lbs. to 7,800 lbs. or more per beam. Under present conditions, the braking power can be, and in many cases is, increased to 85 and 90% of the light weight of the cars, which gives a load of from 9,000 to 10,000 lbs. or more per beam.

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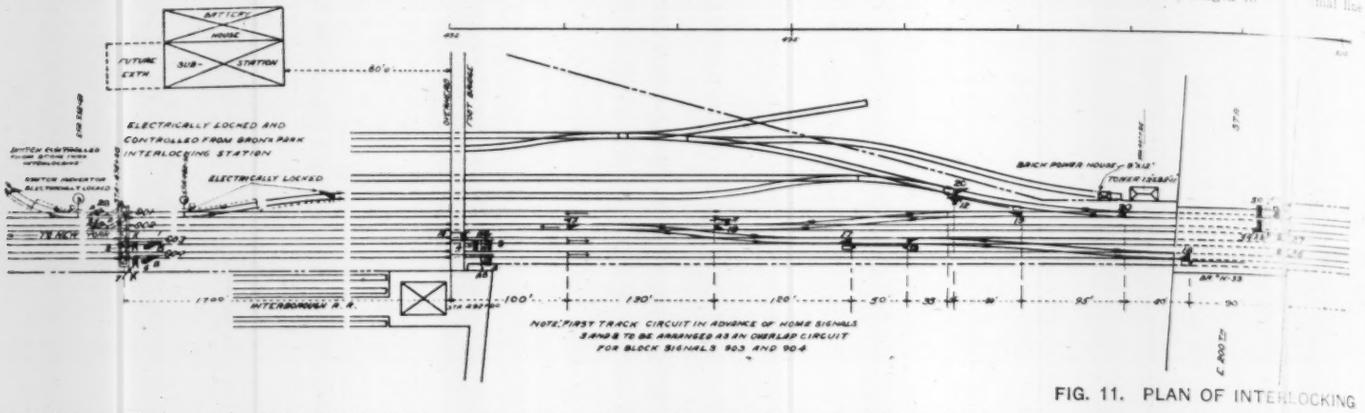
VERTICAL STRESS.—Owing to the large number of brake beams which have become twisted or buckled in service, some have asserted that brake beams are subjected to a severe "transverse" or vertical stress. From a mechanical standpoint there can be no "transverse" stress produced in a brake beam in service. Even under extreme misapplication, which produces torsional or twisting strains, only a slight amount of "vertical" stress will result. The question naturally arises, why do some brake beams become twisted or buckled in service? The committee of your committee show that this is due to the use of brake beams which do not have sufficient strength in


FUTURE EXTN.
SUB-STATION
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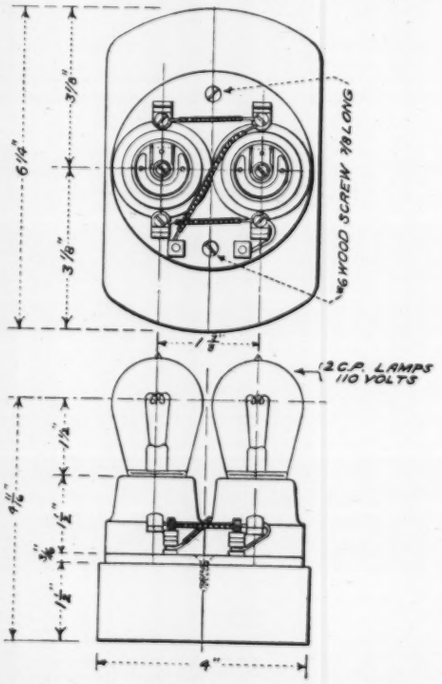

Fig. 10. Electric Light Attachment for Signal Lamp.

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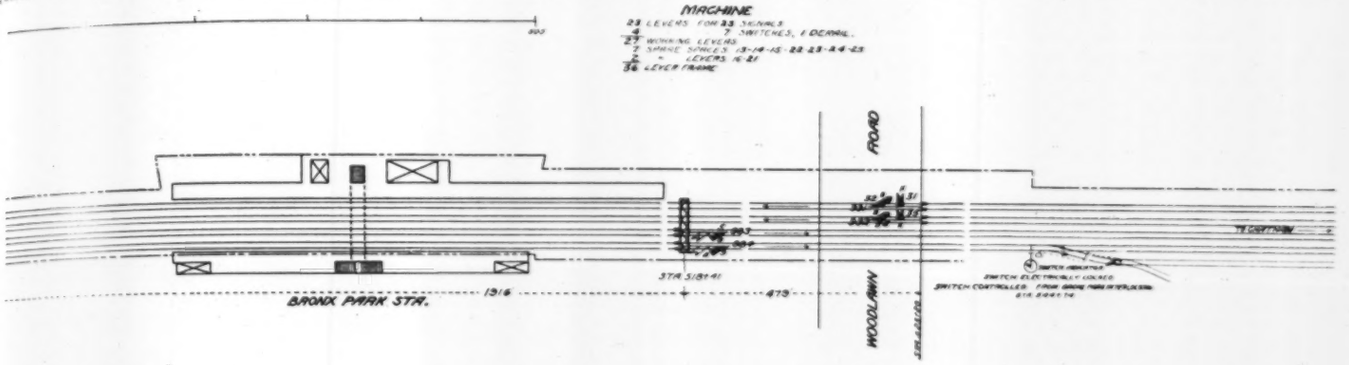

SIGNALS AT BRONX PARK.

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The present M. C. B. standard lever pin which is 13-32-in. in diameter is also generally used and should be maintained, having ample shearing and bearing value for a brake beam of the increased capacity previously recommended, but the diameter of the lever pinhole in the brake beam fulcrum should have our attention. Inspection has shown that the standard of 1⅛ ins. in diameter in many instances is not being adhered to. Many brake beams have pinholes roughly cored, and both too large in diameter and out of round, many being found 13-16-in. to 1¼ ins. in diameter. It is very important that these pinholes do not exceed 1⅛ ins. in diameter, so as to eliminate lost motion as well as to reduce the wear at this point. The tendency to wear increases very rapidly in proportion to the amount of play. In the case of malleable iron fulcrums these holes should be drifted (not drilled) to size. The advantage of drifting the holes in a malleable casting is that they are trued and forced to size without removing the skin or the best wearing part of the material; this process is not only better than drilling, but would also be cheaper for the manufacturer. In the case of wrought iron or steel fulcrums, these holes should be drilled or punched and reamed to size.

APPLICATION.—A proper and efficient brake beam having been determined upon, the next question which naturally arises is that of proper application. While some roads are still applying outside hung beams, the advantage of applying them to the inside of the wheels has been so generally recognized that the number of outside hung beams is now a very small proportion on modern equipment.

As the best results can only be obtained when beams are inside hung, we recommend to the Association that all brake beams be inside hung, and that the present M. C. B. standard height of 13 ins. from top of rail to the center of the face of brake shoes be adhered to on all new equipment. When this height cannot be obtained on old equipment, it is recommended that the beams be hung as high as possible; if provided with rigid heads they should be designed to suit the height at which they are hung. In all cases the lever fulcrum and the center line of the brake beam should be horizontal, which is in line with the applied power. In addition to the above we recommend that this Association adopt as recommended practice the following features of application as shown on Fig. 1, namely:

All brake hangers should preferably be attached to the brake head at the center of same, just back of the central brake shoe lug, so that they will be firmly locked in position by the brake shoe, and by bringing them as close to the shoes as possible, overcoming the tendency of the beam to rotate about the hangers. This will also admit of the use of longer brake hangers, than if they were attached to the brake heads at a point above the center of same, and which is a desirable feature.

Where by reason of design of brake beam the recommended location of brake hanger eye is impracticable an alternate location 2⅛ ins. above the preferred location for brake hanger eye as shown by Fig. A, page 656, is permissible.

The slot for the brake hanger should be limited in dimensions as much as possible, in order to prevent wear and overcome the chattering or excessive movement of the beams up and down with the rotation of the wheels. In order to obtain a minimum play at this point of attachment, a standard size hanger ⅞ in. diameter should be adopted, and this size is now in general use.

In order that the proper release of the brake beam be obtained by gravity, the brake hangers should have an angle as nearly as possible to 90° from a line drawn from the center of the brake shoe to the center of the axle when the shoes are half worn. This will also prevent any possible wedging of the beams.

Third suspension hangers should be used on all brake beams when practicable to prevent the shoes from dragging on the wheels when the brakes are released. They should be attached to flexible (not rigid) brackets, and should have the same exact angle and length as the brake hangers to prevent binding or tilting of the beam.

Chains are preferable to safety hangers, as the yoke and similar forms of safety attachment are often so arranged that they strike the beams, causing a loss of power and a tendency to damage the beam; 51 ins. c. to c. of safety hangers is now generally used and should be adopted as standard.

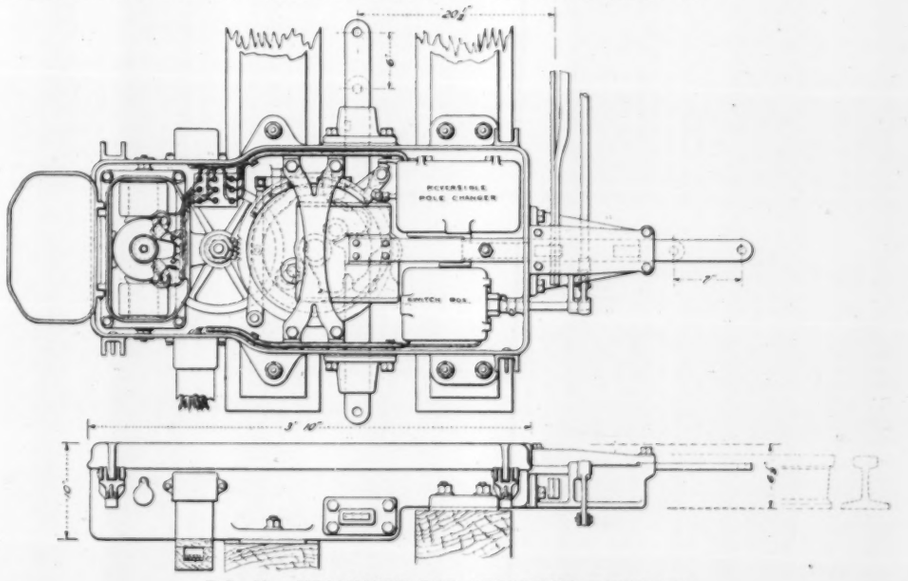

FIG. 13. MECHANISM FOR OPERATING SWITCHES.

FACILITIES FOR TESTING BRAKE BEAMS.—In order to insure the purchasers obtaining brake beams which meet these specifications, if adopted as standard, some provision should be made for testing the beams. Very few, if any of the railroads now have the proper facilities for doing this work.

SUMMARY.—Your committee accordingly recommends for adoption as standard, two brake beams, which shall be known as beam No. 1, for use under cars, having a light weight of 30,000 lbs. or less, and beam No. 2, which shall be used under cars, having a light weight in excess of 30,000 lbs. Both beams shall conform to the following specifications:

1. All beams shall be 60¼ ins. in length from center to center of brake head, with an allowable variation of ⅛ in. in each direction, and shall be proven by the gage shown by Fig. 3, applied to the center and each end of the brake heads, which shall be the standard gage for this purpose.
2. All brake heads shall conform to the M. C. B. standard dimensions, and shall be proven by a standard gage.
3. Attachments for safety hangers shall be 51 ins. from center to center.
4. The angle of the lever fulcrum shall be 40° from the vertical.
5. The lever pinhole shall be 3 ins. in front of the top of the brake head lugs. The variation in either direction shall not exceed 1/16 in.
6. The lever pinhole shall not be less than 1 3/32 ins. in diameter, nor more than 1 5/32 ins. in diameter, and shall be proven by the gage shown by Fig. 6, which shall be the standard gage for this purpose.
7. The maximum distance from the lever pinhole to the extreme back of brake beam should not exceed 9½ ins.
8. For each 500 brake beams, or less, which pass inspection and are ready for shipment, one representative beam shall be taken at random, and subjected by the company manufacturing the beams, and in the presence of the railroad company's inspector, to the following test in a suitable machine:

The beams shall be equipped with suitable heads and shoes, and the shoes placed in contact with castings representing the tread of the wheel; when mounted in this manner, the load shall be applied to the fulcrum in the normal line of pull. As a preliminary to the test a load of 6,000 lbs. shall be applied and released, after which observations for records shall be taken. Beam No. 1, under a load of 7,500 lbs., shall not deflect to exceed .0625 in.; beam No. 2, under a load of 15,000 lbs., shall not deflect to exceed .0625 in.

9. In case a beam shall fail in this test, then a second beam shall be taken from the same lot and similarly tested. If the second beam stands the test, it shall be optional with the inspector whether he shall test a third beam or not. If he does not do so, or if he does, and the third beam stands the test, the 500 beams, or less, shall be accepted as filling the requirements of this test.

10. Individual beams will not be accepted which (1) do not conform to standard dimensions, and (2) that has physical defects. Any lot of 500 beams, or less, sub-

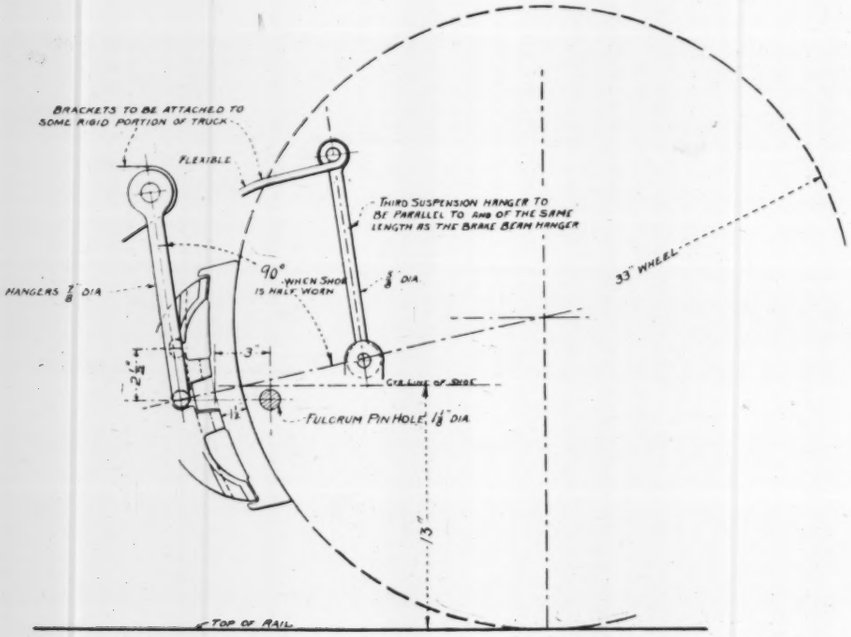
BRACKETS TO BE ATTACHED TO SOME RIGID PORTION OF TRUCK
FLEXIBLE
THIRD SUSPENSION HANGER TO BE PARALLEL TO AND OF THE SAME LENGTH AS THE BRAKE BEAM HANGER
HANGERS 7/8" DIA
90° WHEN SHOE IS HALF WORN
7/8" DIA
33" WHEEL
3"
24"
12"
C/L LINE OF SHOE
FULCRUM PIN HOLE, 1 1/2" DIA
13"
TOP OF RAIL

FIG. A. RECOMMENDED APPLICATION OF INSIDE HUNG FREIGHT BRAKE BEAMS.

mitted for test, that fail to meet the prescribed test (Par. 8) will not be accepted.

RECOMMENDATIONS.—Your committee further recommends for adoption by the M. C. B. Association as recommended practice:

(1) That all beams be inside hung.

(2) That all beams be hung 13 ins. from the rail.

(3) That brake hangers shall be attached to the brake head at the center, and just back of the central brake shoe lug.

(4) That brake hangers shall be ⅞ in. in diameter.

(5) That brake hangers should have an angle as nearly as possible to 90° from a line drawn from the center of the brake shoe to the center of the axle, when the shoes are half worn.

(6) Third suspension hangers should be used on all brake beams. They should be attached to flexible brackets, and should have the same angle and length as the brake hangers.

(7) For safety hangers, chains should be used.

(8) That, in order that these specifications may be generally observed, after September 1, 1910, all cars not equipped with brake beams built in accordance with these specifications, be subject to rejection in interchange on account of improper equipment.

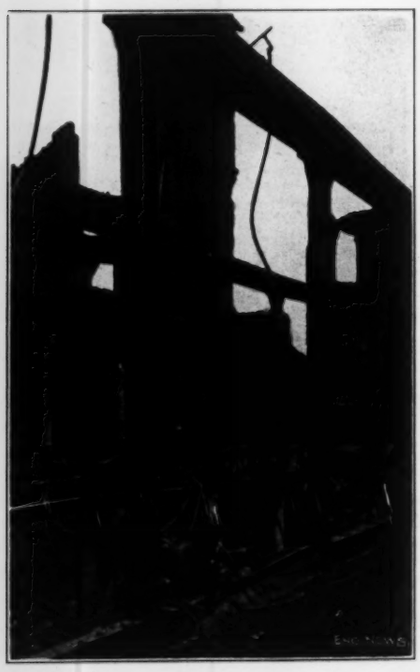

Fig. 1. Interior of a Class "B" Hotel, Showing Cast-Iron Columns only Fairly Well Protected by Wire Lathing.

Four columns out of 40 were bent or warped by the heat. No lugs or brackets were broken on a single column either by earthquake or fire; all flanges likewise are in perfect shape.

MORE LESSONS FROM THE SAN FRANCISCO FIRE.

By J. H. G. Wolf.*

The views of the San Francisco ruins submitted herewith were taken with the idea of illustrating certain lessons in building construction which may be useful to engineers elsewhere.

A notable and striking thing has been the manner in which cast-iron has withstood both earthquake and fire. Since the collapse of the Ireland Building, in New York, a dozen years ago, the writer has always been more or less prejudiced against the use of this material for columns. Fig. 1 shows the interior of a class "B" hotel, in which there must have been a very hot fire. But 10% of the columns are warped by the heat. The protection was of a very flimsy character. The steel girders are all warped and twisted, not one of them being straight. On Powell St. there is an eight-story class "B" building, in which all nine tiers of the columns are standing in perfect condition but the steel girders are either gone or are unserviceable. The three enclosing walls of the building are in good condition, only the front, in which there was a large window area, will require tearing out. This experience is typical throughout the city, cast columns having stood the test of fire much better than steel, where equal protection was given to each.

Fig. 2 shows the manner in which wire glass acted at the Wells Fargo Building. It cracked badly, but in no instance gave way. What it would have done had a hose been directed against it while hottest is problematical. In the California Electrical Building its use was a primary factor in saving the plant. With their private water system they were able to keep the tar and gravel roof wet, and thus prevent the flames from working in from the top. The plant now stands as an oasis in a desert of desolation; is in operation, and is doing a large business.

Fig. 4 illustrates the spalling of granite by the fire, not a new thing at all, but this view was taken as an extreme example. Wherever sandstone was used in combination with granite in a facade, the former stood the flames no better than the latter. This observation applies to the dove-gray or green-gray Colusa sandstone, used generally throughout the city, as well as to the red and brown varieties of sandstone. Concrete stood the flames much better than any natural stone, particularly where it was well and [illegible]stly made. It likewise withstood the earthqual[illegible]ock in an encouraging manner. The vast for[illegible]tion work of the Harbor, built of monolithic [illegible]rete with some steel reinforcement, was und[illegible]ed.

*2531 Benvenue Ave., Berkeley, Cal.

TAR-PAVED ROADS AT SCARBOROUGH, ENGLAND.*

The subsoil of the borough is boulder [illegible] and as one of the chief factors in the life of a tar[illegible] an absolutely dry foundation, the found[illegible] roadway is way of this class consists of 3 ins. of [illegible] of a road are laid 7 ins. of local sandstone or bro[illegible] upon which paved, all interstices being filled in [illegible]bricks, hand gravel 3 ins. thick. a layer of

This formation is consolidated and sh[illegible] with either a heavy horse roller or light 8-ton steam[illegible]er, when it is ready to receive the tar paving, wh[illegible] consists of three coats, as follows:

First Coat.—The first coat is compose[illegible] local limestone gathered from the beach along the [illegible] and broken to a 1¾-in. gage, then placed on the hot [illegible] or drying kiln about 8 ins. thick, and left till thor[illegible]ly dry.

After all moisture has been driven o[illegible] the stone is turned off onto a platform and mixed, [illegible] hot, with cold gas tar direct from the works, about [illegible] cwt. to 1 ton of stone. It is then deposited in [illegible] ready for use, and is better for being kept two or [illegible] months, which remark applies to all classes of [illegible] stone.

Second Coat.—The second coat is compo[illegible] of water-worn gravel from the beach, screened to [illegible]-in. gage, and is prepared as follows: A layer of [illegible] about 3 ins. thick is put onto the hot plates, and is covered by 1¼ ins. screened gas-works cinders about 1 in. thick, then another 5 ins. of gravel covered with a thin layer of cinders, the whole making about 12 ins. thick. When the material is thoroughly dry it is turned over, mixed, and tarred as above—about 1¼ cwt. of tar to 1 ton of material.

Third Coat, or "Topping."—The finishing coat is a mixture of fine gravel and ashes, both screened to ⅝ in. About 5 ins. of gravel are first put on to the hot plates covered with 3 ins. of ashes, then another layer of 5 ins. of gravel, and a further covering of 3 ins. of ashes—in all 16 ins. thick. When dry it is turned over and thoroughly mixed, and then incorporated with tar in the proportion of 2 cwt. of tar to 1 ton of material.

Each coat is well rolled in with an 8-ton roller as it is laid on, and the finished surface is sprinkled with local limestone chippings, which considerably brighten the appearance of the road. The total finished thickness when rolled averages about 4½ ins.

After an interval of about 12 months, or sooner, if required, in about the months of May and June, in fine weather, when the road surface has absorbed the heat of the sun, the surface is painted over with cold tar.

*Extract from a paper by H. W. Smith, A. M. Inst. C. E., Borough Engineer of Scarborough, read before the Association of Municipal and County Engineers, June 1, 1908.

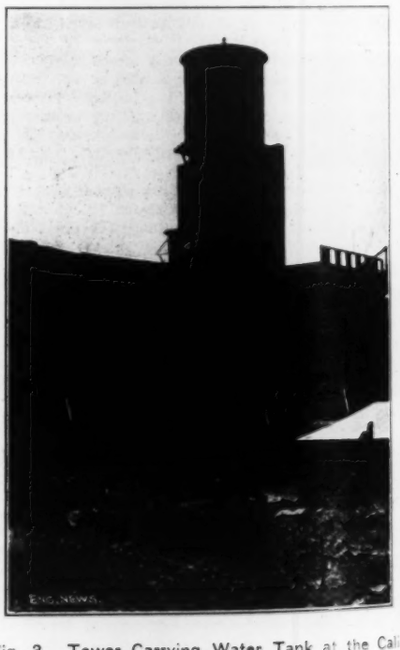

Fig. 3. Tower Carrying Water Tank at the California Electrical Works, not Disturbed by Earthquake.

It was due to this good fortune that the plant was saved. Note design of the Tower.

Fig. 4. Granite Columns of the Postal Telegraph Building, Showing the Worst Example of Spalling by Fire.

The wooden posts were put in a few days after the fire to insure the buildings not collapsing at this corner. The remaining columns of the facade are in fair shape.

and sprinkled with fine gravel and limestone chips, and rolled with a steam roller. This process is repeated every two or three years as necessary, and is the main factor in extending the life of the road. The cost per sq. yd. of a roadway of this class (without foundation) is about 2s. 6d. (60 cts.).

The cost of tarring and dusting (including such slight repairs as may be necessary) is about 1¾d. (3½ cts.) per sq. yd.

The author has experienced some difficulty latterly in obtaining tar of an equal quality to that supplied some years ago before the attention of gas companies was directed to the extraction of the by-products. Nevertheless, by care and rejection of inferior samples, it is still possible to obtain satisfactory results from the tar now obtained without the addition of other ingredients.

The author does not claim for the above form of tar-paved roadway that it is superior to a similar roadway constructed of properly tarred limestone broken to a gage, but ventures to draw the attention of members to it on account of its low cost and as showing that it is possible to produce a satisfactory roadway from material which cannot be described as "ideal" for the purpose.

COST KEEPING ON PUBLIC WORKS.

By Waldo S. Coulter.*

Cost reports naturally fall into two divisions, classified according to the purpose for which they are kept: (a) For ascertaining the variations of force and cost during the progress of the work, stated in periodical reports and kept in sufficient detail to acquaint the superintendent or engineer with the general condition of each estimate item. (b) For ascertaining in considerable detail the various items of cost, to be used for estimating the cost of future work.

The basis of all cost analyses is the timekeeper's daily book. The force reports should be entered in this book in such form as to admit a most complete analysis. The forces engaged on each estimate item should be so entered that the grubbers, shovellers, etc., etc., may be separated. The amount of coal, oil, waste, etc., used, should be shown, an approximate distribution of these being made when they cannot be exactly apportioned. Preferably, this daily book should show the forces engaged and the materials used on each estimate item by gangs, the location of each being stated on the margin, since it is often important to ascertain the cost of a given part of some classification during construction.

This tabulation of the forces in detail must be carefully made, if the various parts of the data are to be consistent and reliable. The forces on a large contract are continuously in a state of flux. Men are being laid off or engaged each hour, transferred from one gang to another, and a given gang may be doing work upon several items during the day. It is evident that, where it can be done, the daily costs should be kept by foremen or inspectors, who are continuously on the job during working hours, and who are in a position to accurately note these hourly changes. This may be done on slips to be collected by the timekeeper.

While the daily books should be kept in detail, only such data are necessary for current reports as will serve to keep the superintendent or engineer informed of an increase or decrease of forces, the extent of the work done on each contract item, size of plant engaged and the financial state of the contract. This report will serve as an approximate check on the engineers' monthly estimate of quantities. This statement, in connection with the regular monthly report of progress, is generally sufficient. In cases where it is desired to analyze the costs of any one gang or to locate a leak, recourse may be had to the daily books.

In addition to the cost of "labor" forces, there are many others to be considered. These may be roughly listed as the administrative, general work, insurance, freight and local tax costs. Administrative cost includes the superintendent, bookkeepers, timekeepers, superintendent's horse, office supplies, etc. General work includes setting up plant, removing same, and such shop work, etc., as is chargeable to the whole contract. These general items cannot be distributed with any degree of accuracy during construction, and can be shown on current reports either undistributed or roughly allotted for current use. Interest on borrowed capital may be included in the current reports, to better show the financial state of the contract.

In connection with the cost accounts it is well to keep, on some classes of work, a supplementary plan showing the location of work done by the various gangs, with tracks, hoppers, etc., from which team and train hauls may be scaled and which may be studied with a view to effecting the best arrangement of the work.

Upon the completion of the contract, a cost sheet should be made, analyzing each item in such detail that the figures may be used for the estimation of costs of future work presenting similar features either wholly or in part.

*Assistant Engineer, U. S. Reclamation Service, Casper, Wyo.

FIG. 2. CHARACTERISTIC CRUMPLING OF SIDEWALK LIGHTS IN FRONT OF WELLS-FARGO BUILDING.

In no instance was the supporting iron or steel protected. The wire glass glazing shown, of the high basement, was badly cracked, but in no instance did it admit flame to the building.

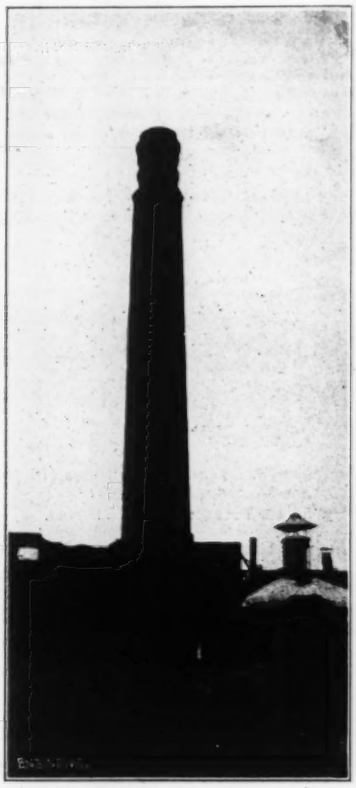

Fig. 5. Brick Chimney of the Wieland Brewery.

This was one of very few chimneys in the city that stood unharmed. That of the California Electrical Co. across the street collapsed in a heap. Note the horizontal cross-section of this chimney.

Fig. 6. New and Old Chronicle Buildings.

The new building (under construction at the time of the fire) had 17 stories; the old building about 8 stories. The column of the new building at the eighth story level next the old building buckled by heat from the hot fire in the old building, and its giving way appears to have allowed the upper six stories of the new building to lean towards the old for a foot or more at the point of maximum deflection at top. The column was not yet protected at the time of the fire.

The proportion chargeable to general items diminishes as the size of the contract increases. For this reason it is best to exclude them from the various contract items on the final cost sheet and state them in the form of percentages. The analysis of the contract items may be better used when uninfluenced by the general costs, unless these are so shown that they can be easily deducted. Depreciation of plant and interest on capital invested are also best stated as percentages and not welded inseparably into the shovelling, teaming and other costs. The following will serve to illustrate the idea:

SOIL EXCAVATION—CLASS A.

	Per cu. yd.
Foremen	$0.008
Grubbers	0.016
Shovellers	0.080
Water boys	0.003
Cost of team haul	0.085
Length of team haul	500 ft.
Cost to haul 1 cu. yd. 100 ft.	0.013
Dumpsmen	0.004
X	$0.176
Administration	5%
General work	20%
Insurance and taxation	3%
Depreciation of plant (Based on labor costs.)	8%
Interest on capital invested. (Based on labor costs.)	1%

All percentages based on amount X.

This Class A may be a small item in a large contract having many items, and consequently the general items be much smaller than would have been the case if this had been a small independent contract. The figures given above can be used for any sized contract working a gang of this size under these conditions, by varying the percentages.

Obviously, interest on borrowed capital should be excluded from this final sheet, since items of unpreparedness should not enter into the estimation of the costs of another contract to be performed, presumably, under normal conditions.

It is often objected that cost data are of little use because of the varying conditions under which contracts for work of the same kind is done, and that the principal qualifications of the estimator are experience and good judgment. This is not to the point, however, since tabulated costs, if properly gathered, are but tabulated experience, and must always be supplemented by a complete knowledge of the conditions and good judgment.

REDUCING THE WEAR OF DRIVING-WHEEL FLANGES ON SHARP CURVES.

The rapid wear of driving-wheel flanges is a serious matter on many railways and divisions having numerous sharp curves, and under such conditions there is usually excessive wear of both rails and wheels, accompanied by the danger of sharp-flanged wheels climbing the rails on curves. The removal of tires for turning and the comparatively short effective life of the tires are also costly results of service on track of this class. The Crown King line of the Santa Fe, Prescott & Phoenix Ry., in Arizona, has a very large number of exceptionally sharp curves, and has had satisfactory experience in the reduction of flange wear by the use of a device for oiling the flanges. This flange-oiler is the invention of Mr. Harry Elliott, Road Foreman of Engines, at Prescott, Ariz., and in regard to it we have the following statement from Mr. W. A. Drake, M. Am. Soc. C. E., General Superintendent and Chief Engineer:

By this device the engineman in the cab can apply a film of oil to the driving wheel flanges, this being done in such a way and so small a quantity being used that it does not spread to the tread of the wheel or the top of the rail, and in no way affects the driving wheel traction or adhesion. This has been in use on some of the locomotives of the Santa Fe, Prescott & Phoenix Ry. for 14 months, and at no time has the oil in any way conflicted with the wheel traction. The wheels of one of these locomotives have made 40,000 miles without perceptible wear or suggestion of tire turning on account of flange wear. Before the flange oiler was used, tires were turned after running 20,000 miles. No estimate has been made of rail wear or of decreased risks on account of wheels climbing the rail. These results were noted on the Crown King road, where more than half of the line is curved, and most of the curves have a characteristic of 16°. This arrangement has not been applied to all the locomotives, but it soon will be. Its use on this line has not been of sufficient length to make estimates of the saving in dollars and cents, but it must be very great, and the device should interest all superintendents of motive power and those in charge of maintenance-of-way where curves of over 5° and 6° obtain. It is not likely that the ordinary lubricating oils can be used in this way; California fuel oil so far seems to be the only oil filling the requirements.

Fig. 1 shows the arrangement as applied to a consolidation locomotive; this engine has cylinders 19 × 26 ins., driving-wheels 4 ft. 2 ins. diameter (all flanged), and a driving-wheel base of

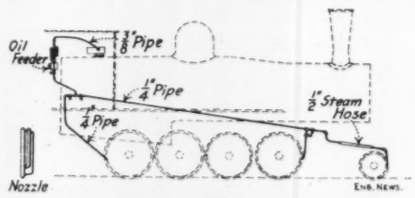

Fig. 1. Arrangement for Oiling the Flanges of Locomotive Driving Wheels.
Harry Elliott, Prescott, Ariz., Inventor.

13 ft. 6 ins.; it has a weight of 128,000 lbs. on the driving wheels. According to recent information this engine has been in service 17 months since its equipment with the flange-oiler, and has made over 50,000 miles; the front flanges have worn not more than 1/16-in. and the back flanges show practically no wear. The engine runs on a line having 187 curves in 27 miles; 50 of these curves are of 16°, and the others are 15°, 14° and 12°. There are also ten switchbacks with 16° curves and 3½% grades. It will be seen that steam is taken from the turret head in the cab and piped to an oil feeder, shown in detail in Fig. 2, from which ¼-in. pipes are led to the front and rear driving wheel tires. The oil is not now used on the truck wheels, as their flanges do not wear or cut badly. The driving-wheel flanges are said to be as smooth as glass. The oilers on the front wheels are in use all the time; those for the rear wheels are used only when the engine is backing. It will be seen by the sketch in Fig. 1 that the oil pipe has a nozzle to throw the jet of steam and atomized oil against the face of the flange. As to the device and its operation, Mr. Elliott, the inventor, writes as follows:

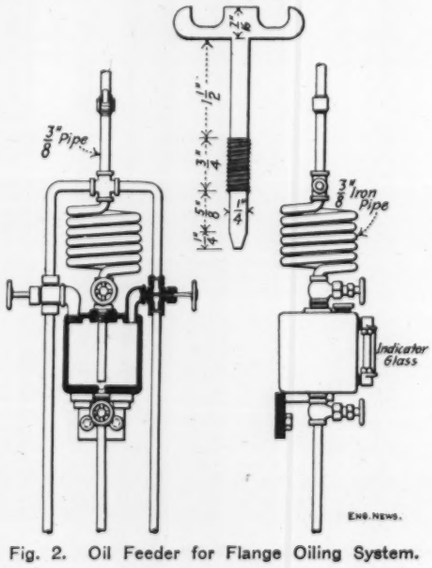

Fig. 2. Oil Feeder for Flange Oiling System.

I hold patent No. 818,364, issued April 17, 1906, for a system of lubricating a wheel flange or rail, comprising an oil feeder or receptacle and a pipe in communication with this receptacle, and with a source of steam supply, under reduced pressure and temperature; this pipe terminates in an orifice in proximity to the wheel flange and directs a current of steam and atomized oil against the surface of the flange or rail. Crude oil is the cheapest and best, as it adheres to the flange and spreads less, but any kind of heavy oil can be used. One gallon should be sufficient for 500 miles or more. The steam should be used to form a good jet of steam at the nozzle, and to strike the flange with enough force to spread the oil in a circle about 1 in. [illegible] the wheel revolves it spreads the oil all over the surface of the flange and carries it away from the wheel. Enough oil should be used to keep the flange covered all the time when running, but should be shut off when the engine is standing for any length of time. More steam is required in cold weather, and when the pipes are on the outside of the jacket account of condensation at low pressure. The oil feeder should hold not less than half a gallon, and the coil should have at least six coils to keep the oil cool. Where the oil is used continuously the flanges will run perfectly smooth and show no perceptible wear; the oiling to be as long as the tread of the wheel before requiring to be turned.

In this connection it is of interest to refer to the use of a water jet to reduce flange wear. This was tried on the Pennsylvania R. R. as long ago as 1871, with a fan-shaped jet directed against the flange. It is said that moisture caused dirt to collect and make a "greasy" rail for following engines, and the experiment was not continued. For several years past the Duluth, Missabe & Northern Ry. has used a somewhat similar system, and we are informed with successful results. The 90-ton consolidation engines take ore trains of over 2,000 tons (behind the tender) down a 2% grade about seven miles long and having a number of curves. In descending this grade with brakes set, as well as in ascending with heavy trains of empty cars, the driving-wheel flanges were subject to severe wear. From a connection at the back head of the boiler ⅜-in. pipes were led to the front and back drivers, the pipes being drawn down at the ends to form nozzles 3/16-in. diameter. With the water jets in use the flange wear is said to have been greatly reduced. In ordinary service, only enough water is used to moisten the rail, and there is said to be no trouble from the wheels slipping on the wet rails. If the rail was "greasy" a strong jet of water could be used to clean it and so prevent slipping of the wheels. The same arrangement has been applied to 60-ton switching engines at the ore docks, these engines working on sharp curves and through crossovers.

AN AUTOMATICALLY DUMPING PAN ELEVATOR for charging a concrete mixer was recently employed by H. C. Lindsley & Son, of Kansas City, Mo., contractors, in constructing bridge abutments on the Kansas City Belt Line Ry. The apparatus consists essentially of a steel pan of the proper size to hold the required charge or batch taken from barrows, of a cage in which the pan is mounted and of a guide frame equipped with the necessary sheaves, and ropes for hoisting and lowering the cage. In operation the pan is filled at ground level and then hoisted to the mixer level, where it automatically empties into a feeding chute. The cage is operated from the engine that operates the concrete mixer. The apparatus is being put on the market by its designers.

RECENT FIRE TESTS made by the British Fire Prevention Committee on light steel rolling shutter doors, made by the Kinnear Mfg. Co., of Columbus, Ohio, showed that flames will not pass through or around such doors although considerable heat is radiated, and that they can be operated after being subjected to high temperatures and strains by fire and water.

Two tests were made, one with a 7 × 8-ft. door fixed on either side of the opening in a wall 14 ins. thick, and the other with a door of the same size fixed on the inside of the opening only. The double door was heated for 4 hrs. while the single door was only heated 2½ hrs. The average temperature, after 2 hrs., on the interior of the hut with the double doors was about 1,700° F., while in the other hut the average was about 1,500° F.

LIGHT RAILWAYS IN ENGLAND are not always "light" as far as construction works are concerned, and in some cases they appear to differ from main lines only in being single track and having rather sharp curves and grades. In a recent number of the London "Engineer" is a description of a line built by the Glasgow & South-western Ry. as a feeder, 19½ miles long, which has been four years under construction. It is single track, with heavy bridges, but its rails are "only" 80-lb. per yd., as compared with the 90-lb. rails on the main line. The maximum grades are 1.55%, and the sharpest curves are of 1,000 ft. radius.

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The successful launch on June 8 of the new Cunard steamer "Lusitania," the largest vessel ever built, is a noteworthy event in shipbuilding annals. As our readers will recall, this is one of the two new ocean greyhounds designed and built by the Cunard company at the instance of and with the cooperation of the British government, for the express purpose of regaining for British shipping the Atlantic speed record, which after being held by British vessels for many years was captured by the German steamship lines some ten years ago.

The hull of the "Lusitania" has the enormous length of 785 ft. over all, and her beam is 88 ft. These dimensions, with the extraordinary molded depth of 60 ft. 6 ins., give the vessel a displacement of 38,000 tons. Practically all the huge vessels which have been put on the Atlantic lines during the past half dozen years and broken the records for size have been cargo carrying boats; but these new Cunarders have been given this extraordinary size in order to carry sufficient propelling machinery and coal to break the Atlantic speed record; and not only to break it but to lower it to a point where no other country or shipping line will care to compete. In this great hull there will be placed 25 cylindrical boilers with a total grate area of 3,950 sq. ft. and heating surface of 160,000 sq. ft. These will burn 5,000 tons of coal on the transatlantic voyage and will furnish steam to steam turbines of 68,000 HP. mounted on four propeller shafts. This is expected to give the vessel a sustained speed at sea of 25 knots. Assuming the distance from Sandy Hook lightship to Daunt's Rock, off Queenstown Harbor, at 2,775 knots, this speed would reduce the transatlantic voyage to about four and one-half days.

The sister vessel to the one just launched, the "Mauritania," will take the water a month hence and it is expected that both these great ships will have their propelling machinery in place and be ready for service in the spring of 1907.

The heat problem in the New York subway is such a novel problem in engineering and knowledge concerning it is of so much importance in view of the rapid extension of electric tunnel traction, that Mr. Rice's report on the subject, printed in our last issue, will certainly be carefully studied by the engineering profession.

It is rather remarkable that the problem, in definite form, has not been encountered before. As we pointed out a year ago, until the summer of 1905 it had been tacitly assumed that the New York subway was to be a cool and agreeable retreat during the sweltering days of July and August. Indeed, if we mistake not, among the multitude of prophets who foretold disaster, while the subway plans were still being fought over, there were those who averred that the subway would be so chilly in summer that the sudden change from the hot air of the streets would create an epidemic of pneumonia among subway travelers. As we showed a year ago, the subway is warmer than the streets and not colder, because there is being constantly poured into the six-mile section from Brooklyn Bridge to 96th St., according to the estimates of Mr. Rice's report, over 25,000,000 heat units per hour, on the average for the whole twenty-four. This is equivalent to the total heat given out from the combustion of nearly two tons of coal per hour.

The reason why the New York subway is hot is because the heat is poured into it faster than it is carried off by conduction into the ground and through change of the air. The reason why the Boston subway and other subways have never been uncomfortably warm, is probably because of the smaller amount of electric power used therein, meaning a smaller amount of heat liberated, and because the heat has passed off more rapidly owing to the lower average temperature. Boston may have an occasional summer day with as high a temperature as New York; but the average summer temperature is considerably lower than New York. The same thing is true of London; and it is also true that the London tube railways with their cast-iron lining in direct contact with the London clay probably conduct the heat away more rapidly than tunnels through loose earth lined with masonry and waterproofing like the subways of New York and Boston. The only other electrically operated subways antedating the New York subway are those of Paris and Budapest; and while the temperature is higher in those cities than in London, the amount of electric current used is far below what is used in New York. It will be understood, of course, that the energy used is quite largely dependent on the rate of acceleration; and the very high acceleration adopted in New York in order to cut down the schedule time between terminals, is to no small degree responsible for the difficulties now being experienced with subway heat.

In studying this problem a year ago, from the meager data then available to us, we concluded that the bulk of the heat passed off from the subway by change of the air. Mr. Rice's studies appear to show that most of the loss of heat is by conduction through the floor, sides and roof of the subway, particularly the latter, and that only a small portion of the loss of heat can be credited to the change of the air. We are speaking now, of course, of summer conditions. In the winter the subway temperature is often little higher than the average ground temperature, while there is an average difference of 25° between the subway and the outside air. It would seem, therefore, that at this time a large part of the loss of heat from the subway must be due to the change of air, although, of course, the loss of heat through the roof is much greater than in summer.

The possible effect of the gradual accumulation of the heat in the ground surrounding the subway, to which we referred a year ago, is a matter deserving further investigation. The engineers concluded from their study of the conduction constants that since most of the subway heat passes off through the roof the deepest sections of the tunnel ought to be the hottest. On the contrary, the deep section under Murray Hill is the coolest portion. The reason ascribed for this is the presence of moving ground water, in that deep section, which carries off the heat. It seems to us doubtful whether this is the true explanation. As we understand it, this section of the subway is a tunnel through rock, more or less seamed and broken it is true, but with no such opportunities for the presence and movement of ground water as might exist in sections of the subway farther down town, near Canal St., for example, where the structure is surrounded by sand.

What appears to us a more likely reason for the lower temperature in the tunnel under Murray Hill is the fact that the solid rock through which the tunnel is driven is a much better conductor of heat than the earth through which the southern part of the subway is made. It is true that other portions of the subway are in rock excavation, but they have a rectangular cross-section and more or less loose filling around them, whereas under Murray Hill the subway is two separate double-track circular tunnels.

The heat problem in the New York subway is of interest, of course, because of its bearing on future city subways and other electrically operated passenger tunnels. The new tunnels of the Pennsylvania R. R. entering New York City, for example, will have powerful electric locomotives and doubtless a dense traffic. Will its cast-iron lining and location in the mud under the river suffice to carry off the heat and keep down the temperature? If it does not, the cooling of the tunnel by change of air will be vastly more difficult than on the Rapid Transit subway, with its frequent stations and close proximity to the surface.

The New York Central's new tunnels also will have a very dense traffic, and their cooling, in case overheating should exist, would be far from an easy problem.

In Philadelphia, with its higher summer temperature, trouble with heat in the subway may be expected before traffic increases to nearly the density of the New York subway.

The St. Clair tunnel will prabably escape all trouble because of the low temperature of the locality, the cast-iron lining of the tunnel and the fact that the tunnel being a submarine one lies in saturated ground. Observations of temperatures in this tunnel, however, will be of great interest to indicate what is the rate of heat loss through the tunnel walls under such conditions.

The bill removing the internal revenue tax from alcohol used for mechanical or industrial purposes has passed Congress and been signed by the President, and it will doubtless have the most important commercial results of any law enacted by the present Congress. In order to be free of tax the alcohol must be "denatured" under direction of Government officials; that is treated by some process which will so change its nature that it will be impossible to use it for drinking in any form. In the testimony before the Congressional committees, much has been made of the probable use of alcohol for small internal combustion engines instead of gasoline. It is doubtful, however, whether any considerable commercial success is possible in this field, at least until the price of gasoline goes much higher. It is the excessively high price of gasoline in Germany that has led to the development of the alcohol motor there. It is true that alcohol can be produced at a very low cost from sugar refinery wastes and similar sources; but such alcohol made in this country will be all absorbed by the paint and varnish and chemical trades at much better prices than the automobile owner could afford.

For lighting purposes the alcohol lamp with incandescent mantle has a more promising field, and promises to become an important supplement to kerosene in places where gas or electricity or acetylene are unavailable.

REDUCING THE COST OF CENTERING AND FORMS IN REINFORCED CONCRETE BUILDING WORK.

Instances are not uncommon in reinforced concrete building work where the cost of centering and forms amounts to one-half the total cost of construction. Ways and means for reducing this tax are evidently worthy of the most careful thought, yet while we have had volumes of discussion on the theory and calculation of beams and columns and arches in reinforced concrete, there is an almost total lack of printed infor-

mation on economical form work or the cheap manufacture, handling and placing of concrete and its reinforcement. It is not expected to supply this deficiency here, but in view of some recent attempts that have been made to eliminate the undue proportions of the cost of form work a few remarks on this problem will be presented for consideration.

The cost of form work for buildings may be roughly divided into cost of materials, cost of fabrication and cost of removal. About the only chance of reducing the cost of materials lies in lessening the amount of material used. In respect to cost of fabrication and erection, economies may be obtained generally by planning the forms so that the maximum amount of the work of fabrication is done in regular shops where machine and piece work economies are possible, and so that in erection unskilled labor can be made use of to the greatest possible extent. Generally speaking, forms that are designed to permit of rapid and easy erection will also permit of rapid and easy removal. These points will, perhaps, be made clearer to many if we develop the discussion briefly.

For general building work of concrete molded in place, no other material for forms takes the place of wood. The conditions are such that despite the most careful attention to duplication of shapes and dimensions in structural details, the form work must be altered more or less from story to story. In shifting operations from building to building, the necessity for alterations is obviously even greater. No other material lends itself to these alterations with so little waste and so small an expenditure in labor and plant as does wood. Wood, therefore, is essentially the standard material for form work. No reduction in the price of this material seems possible; in fact lumber of all kinds has increased in price in the last year or two, and everything points to a continued increase. Hence it is that about the only means that lies open for reducing the cost of materials consists in lessening the amount of material used. A little later some of the methods of reducing the amount of material used will be indicated.

Turning for the moment to a consideration of the means for reducing the cost of fabrication, it is clear that material economy may be effected by planning the forms so that they can be built in regular shops. If the fabrication of the whole mold ready for use in this way is impracticable, it is at least possible to purchase the lumber cut to dimensions ready for assembling at the work and thus obviate all but the simpler carpenter work. To facilitate erection and removal of forms, eliminate nailing. By using bolts and nuts, clamps and yokes, nailing has been almost entirely done away with in much recent form work. This brings two advantages; the erection and removal can be trusted to unskilled labor working under an experienced foreman, and there is less destruction of the lumber, a serious matter when nailed forms have to be wrenched and pried apart. Of course, this all involves thought and planning, but where the falseworks aggregate in cost half the cost of the whole work, thought and planning are warranted.

In reference now to specific methods of reducing the amount of materials for form work, the first method that will occur to all is to make repeated use of material. It may be said at once that this method has already been very carefully worked out by the larger builders of reinforced concrete structures. They in many cases have so standardized and systematized their work that an exceedingly small amount of form work is made by repeated use to serve for a very large job, and then to a large extent be shipped to succeeding jobs. This again to be worked successfully requires study and planning of the highest character.

So far we have spoken of the form work as an independent structure from the permanent building and this, of course, is exactly what it is in the majority of building work. Recently, however, considerable attention has been given by practical builders to arrangements whereby the forms are designed to be erected and to remain a part of the permanent structure. The beginnings of this idea were, perhaps, in connection with buildings having brick walls and reinforced concrete floors and framework. By building the walls first and leaving spaces for the wall columns and girders it was found possible to make the spaces serve in lieu of timber forms. The higher development has been to cast the shell of the form in reinforced concrete which remained in place as a part of the structure. Like many other developments in reinforced concrete work this one had its origin in Europe, but it is of a single American example that we propose to speak here.

In constructing the interior columns of a factory building recently erected by the Bush Terminal Co., of Brooklyn, N. Y., cylindrical shells of cinder concrete 1½ ins. thick and cast in proper molds were set end on end to the proper height to form a mold for the column concrete. Spiral reinforcement was adopted for the columns and this was molded into the shell so that the placing of the column form also placed the column reinforcement. There was gained at once by this scheme of form work a cinder concrete fireproofing for the column, the placing of the form and reinforcement in one operation by unskilled laborers, and the elimination of all labor for removal of forms. As for the shells themselves, their cost was certainly not greater and was probably less than would have been cylindrical molds in wood.

With all the reduction possible in material and labor the centers and forms for building work of concrete molded in place are very costly. In Europe for some time and recently in this country attention has been turned to the possibilities of building construction of columns, girders and slabs separately molded and erected much as would be similar members in steel or timber. Whatever may be said in other respects of this type of construction as compared with monolithic concrete construction in place, it certainly has the advantage of reducing the cost of form work. As a specific illustration of this fact we have some recent work described by Mr. E. P. Goodrich, M. Am. Soc. C. E., in an address to the Association of American Portland Cement Manufacturers at Atlantic City, N. J., this week.

Mr. Goodrich had to construct for the Bush Terminal Co. of Brooklyn, a number of one-story warehouses with ground floors of concrete brick walls and reinforced concrete slab and girder roofs on interior columns. All the reinforced concrete columns, girders and roofing slabs were cast on the ground and then erected. Mr. Goodrich's account of the work was substantially as follows: For molds for columns cast on one side only three pieces were needed in place of four that would have been necessary had the columns been molded upright in place; this effected a saving of 25% in materials for molds, besides doing away with clamps, bolts and bracing. Another advantage obtained by these column forms, which was also shared by girder forms, was that the side boards could be removed after 24 or at the most 48 hours, and used again two or three times during the interval which they must have been left in place if the molding had been done in place. This alone saved 50% in materials for forms, as only the narrow bottom pieces were needed in any great numbers. A much greater saving was made in the centering for the roof slabs. The concrete ground floor was laid as soon as the columns and girders had been erected. On this flat surface ordinary building paper was spread and the roof slabs marked out by narrow strips of wood of a height just equal to the desired thickness of the slab. The reinforcing rods were then placed and the concrete deposited. Altogether these various savings reduced the cost of the building to one-quarter of what it would have been if built with forms in place.

LETTERS TO THE EDITOR.

Reinforced Concrete Piles at the Atlanta Terminal Station.

Sir: In view of the article on reinforced concrete work at the new railway terminal station at Atlanta, Ga., published in Engineering News of April 12, we beg to call your attention to the following facts: The reinforced concrete piles and the means employed in d[riving] as described, are covered by the U. S. Letter[s] 611,909, granted on Oct. 4, 1898, to Francois [Hennebique] and now owned by this company. Accordi[ngly] spring of 1905 suits were brought both again[st] more Ferro Concrete Co. and the Atlanta [Terminal Co.] for the infringement of this patent by the [Terminal Co.] Atlanta. The suit against the Baltimore F[erro] Co. was settled by the payment by it to us [of a] lar license fee of 10% on the total contract [price] piles in question, and the entry, on May [2], decree which adjudged the validity of our [patent] infringement, awarded costs to us, and or[dered] petual injunction against the Baltimore F[erro] Co. The suit against the Atlanta Terminal C[o.] upon discontinued. Very truly your[s],

Hennebique Construction Co[.],
R. Baffre[y], President.

1123 Broadway, New York, N. Y., April 2[1], 1906.

Reinforced Concrete Arch Culvert D[esi]gn.

Sir: In your issue of May 24, Mr. Lut[en] makes a very able comparison between a reinforc[ed] concrete beam and reinforced concrete arch, as used [for] railroad culverts. The wri'er would like to sugge[st] an improvement in Mr. Luten's arch, the use of [a] segmental rather than semi-circular arch. A true a[rch] of more than 120° is impossible. (Baker, "Treatise on Masonry Construction," Art. 631-2.) The length of intrados of a segmental arch is considerab'y shorter than the length of intrados for a semi-circular arch of the same span. Doubtless some would argue that the abutment for a segmental arch should be heavier than for a circular arch, which would be true if there were no earth filling back of the abutment. However, frequently, in fact, in most cases, the abutment for railway arch culverts must be made heavier to resist the earth pressure than would be required for the arch thrust. From this it would seem that the segmental arch would allow even a lighter abutment than a semi-circular arch as the segmental arch thrust would take up some of the thrust resulting from the earth filling; however, the writer would not recommend a reduction of the abutment below what is required for resistance of the thrust of the embankment.

Referring to Mr. Luten's method of proportioning culverts: He limits the fill to 10 ft. over crown of arch. I should like to inquire what addition is necessary for heavier fills; say fills of 50 ft. over crown.

Yours very truly, B. F. Beckman,
Engineer, Maintenance-of-Way, Ft. Smith & Western R. R.

Ft. Smith, Ark., May 31, 1906.

A Convenient Method of Finding Square and Cube Roots.

Sir: As it is not always convenient for engineers to consult a table of squares in feet and inches, I give herein a short method of finding square and cube roots of numbers by using an ordinary table of squares and cubes found in nearly every handbook. I have used it for several years and have found it convenient and sufficiently accurate for all ordinary purposes. I have never seen it published, so submit it for your columns.

For square roots the method is as follows: Find in a table of squares the square nearest to the number whose root is desired. Take the difference between the given number and the nearest square in the table and divide it by twice the number in the table, which is the exact square root of the square chosen. The quotient will be the correction to be added to or subtracted from the exact root given in the table.

For example; suppose the square root of the sum of the two numbers 9362.83 and 9774.71 is required. The sum of these two numbers is 19137.54. The nearest number in the table of squares is 19044. The difference is found to be 93.54 and the square root given in the table is 138. Dividing 93.54 by 2 × 138 gives .3389 and this added to 138. gives 138.3389, the root desired. The exact square root of the given number is found to be 138.3385, which differs from that found by the short method by .0004 which corresponds to an error of about 1-200 of an inch if the original numbers given are in feet. The error will seldom be greater than this for numbers of this size and will often be much less.

The process of arriving at this approximate method is as follows:

Let M^2 = the number whose square root is desired.
M_1^2 = the nearest square given in the table.
x = the square root of M_1^2, given in the table.
$\triangle x$ = the correction to be applied to x to get the desired root.

Then $M^2 = (x + \triangle x)^2$

$$= x^2 + 2x\triangle x + \overline{\triangle x}^2$$

Also $M_1^2 = x^2$

Subtracting, $M^2 - M_1^2 = 2x\triangle x + \overline{\triangle x}^2$

and $$\triangle x = \frac{M^2 - M_1^2}{2x} - \frac{\overline{\triangle x}^2}{2x}$$

Since Δx will be small compared with x the term $\frac{\Delta^2}{2x}$ is dropped and $\Delta x = \frac{M^2 - M_1^2}{2x}$.

The cube root may be found in a similar way, the equation for the correction being

$$\Delta x_1 = \frac{M_3^3 - M_2^3}{3x_1^2}, M_2, M_3, \text{ and } x_1 \text{ all being given.}$$

As an example, the cube root of the number 19137540 by this method is 267.4834. The exact cube root is found to be 267.4834, giving a difference of .0000, about 1-100 of an inch if the given number is in feet.

The position of the decimal point in all cases must be determined by inspection.

Sincerely yours, H. E. Eckles.

Bridge Dept., C., B. & Q. R. R., Chicago, Ill., May 23, 1906.

A Method of Designing Reinforced Concrete Columns.

Sir: In your issue of April 26 "Engineer," of Toronto, suggests a method of design of reinforced concrete columns. The writer feels that there are a number of deficiencies in the theory propounded and wishes to suggest a few queries and possible modifications.

(1) It is well known that the stress-strain diagram for concrete of most mixtures and ages is not a right line. In fact, it so far differs from a right line, that concrete columns which have been tested to destruction, and on which careful measurements of the actual compression were taken during the process, showed conclusively that the steel was not carrying more than one-quarter of what it would have been intended to do according to the hypothesis of "Engineer." Thus the 15 assumed by him "for the sake of argument" is almost as far wrong as the specification quoted in his letter.

(2) The writer has never seen a concrete column fail by a shearing in the manner described by "Engineer" along the plane of theoretical maximum shear, even when no steel reinforcement was employed. The writer would be most interested in hearing of the results of such tests if others know of them. In the writer's experience failure has always occurred by the methods of "bulging," more or less modified.

(3) Allowing for the moment the possibility of failure along a diagonal shearing plane, how is the shear in the concrete to be transferred to the steel? Manifestly, the two steel bars shown in the diagram prepared by "Engineer," which are near the upper end of the plane of shear can afford practically no assistance in preventing shear. The two bars near the lower end of the plane will be certain to be pushed out of the side of the column unless tied to the others by very strong ties. This point might provide "Engineer" with a basis for the computation of his ties. But further, how is the shear in the concrete to be transmitted to the two steel rods which might offer some assistance? Only by the bearing of the concrete against the sides of the rods. But what length of rod is to be considered as providing such bearing and what is the allowable stress for such action? Some experiments lately conducted by the writer showed conclusively that the additional shearing resistance due to steel rods was very small—practically nothing.

The best place in a column for reinforcement rods designed to take up shear is at its center.

If "Engineer" will consult the report of Considère's tests ("Experimental Researches on Reinforced Concrete," by Armand Considère, McGraw Pub. Co., New York, N. Y.) he will find a more or less "rational method of obtaining the bulging or swelling force at the circumference" which he may find interesting.

Yours very truly,

E. P. Goodrich,
Chief Engineer, Bush Terminal Co.

Foot of 43d St., Brooklyn, N. Y., April 30, 1906.

Sir: In a letter by "Engineer," published in your issue of April 26, a method of designing concrete-steel columns is given which, in my judgment, has serious faults. Theoretical calculations as to the exact or even approximate relative loads that will be taken by steel and concrete, both in compression in a member, are all upset by the fact that the concrete shrinks in setting and puts the steel under an initial compression, also by the fact as determined by experiment (Considère's, for example) that longitudinal rods embedded in a concrete column add little or no compressive strength.

Even assuming that more than 25% of the load is taken in compression by the steel, as found by "Engineer," there is another fault or omission in the deduction. It concerns the amount of shear taken by the concrete and steel, respectively. Assuming a column of 100 sq. ins. designed by the method given by "Engineer." It will have 2.5 sq. ins. of steel reinforcement. The direct load taken by steel will be about 19,000 lbs. and that taken by the concrete about 49,000 lbs. The steel thus takes 28% of the load. Of the 49,000 lbs. of shear in the diagonal direction the steel takes 42,000 lbs. and the concrete 7,000 lbs., roughly. The steel thus takes a shear corresponding to about 86% of the load. How does this extra shear get into the steel? In amount, for this case, it is 86 — 28 = 58% of 49,000 or 28,000 lbs. on the side of four rods about ¾-in. square. The pressure for this extra 7,000 lbs. per rod must come from the concrete. This force, if it had any actual existence, would break the rod out of the side of the column.

The same line of reasoning applies against so-called shear bars as a means of transferring stress in rods into the concrete. How can steel be stressed to 12,000 lbs. per sq. in. in shear when that force would put a pressure on the concrete which it is unable to stand? Rods in any and every direction that tie concrete together and thus prevent disintegration will of course aid in the strength, especially in the way of deferring ultimate failure. If stirrups strung along a reinforcing rod in a beam defer ultimate collapse or distribute cracks that would otherwise be concentrated in a few points, it is not warrant for assuming that they are in shear, under safe loads, in amounts that would crush the concrete. We do not gage the supporting power of a nail driven in wood by the shearing strength of the nail but by the bearing power of the wood. Yours very truly,

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., April 27, 1906.

[Proofs of the above letters were submitted to "Engineer" and his reply follows.—Ed.]

Sir: The reinforced concrete industry, while comparatively new in this country, has been vigorously pursued since its inception, and the general principles of economical design are now being rapidly brought into compact and workable form. Surely there must have been during this period American engineers or contractors who have made or witnessed more or less extensive tests on reinforced columns, and these should be in a position to give the profession valuable information from which we may be able to develop a rational formula for column designing. It is the almost total lack of such information (from American sources) which, as the writer stated in his article of April 26, prompted him to submit the discussion contained therein.

This discussion was founded on purely theoretical assumption, and the writer has to thank your correspondents for the possible flaws which they have found in it, while at the same time confessing to a feeling of disappointment in that they have apparently overlooked the main point, which was to "evoke a general discussion of the best methods of designing reinforced columns."

Mr. Godfrey and Mr. Goodrich have told the writer wherein his theoretical discussion is weak, and Mr. Goodrich confesses to having had experience with columns that failed by "bulging." Will they now assume a vertically imposed load of 32,000 lbs., as did the writer, and design a column to safely support it? We can then see how far their results differ from those obtained by the writer's analysis.

Replying to Mr. Goodrich's letter: It is a well-established fact that the modulus of elasticity of concrete in compression is not a constant quantity, and that the stress strain curve is somewhat closely related to a parabola, but that portion of the strain curve between a very moderate unit stress and the stress of safe working loads is so very nearly a straight line that we can assume it to be so without material error. As for the ratio 15 between the modulus of elasticity of steel and that of concrete, the writer has followed closely the recommendations of Professors Hatt, Talbot, Captain Sewell and others, and Mr. Goodrich himself in his recent discussion of Captain Sewell's paper on "economical design of reinforced concrete floor systems" (Proceedings of the American Society of Civil Engineers, March, 1906), states that he believes a ratio of less than 15 to be really too small.

It would be interesting if Mr. Goodrich would give us more explicit information regarding the size, reinforcing, age and loading of the columns which in his experience failed by bulging, and also the experiments which showed that the additional shearing resistance due to steel rods was practically nothing.

If we are to conclude from his statement in paragraph (1) that the steel actually carries less than 25% of the total loading attributed to it by the writer's hypothesis which allowed it about 28% of the total load of the column, then the steel is actually carrying only 7% of the imposed load. If such a condition actually exists it will be more economical (in money cost) to omit the steel altogether and build a solid concrete column.

This supposition is followed up by Mr. Godfrey, who adds that "longitudinal rods embedded in a concrete column add little or no compressive strength." Is it possible that we are all "barking up the wrong tree" in attempting to reinforce concrete columns. When Mr. Godfrey says "this force, if it had any actual existence, would break the rod out of the side of the column," he is losing sight of the tie rods which are there for the purpose of preventing any such lateral motion.

The writer has had prepared a series of concrete columns reinforced in various manners and varying in length from 10 to 24 times the least side, which, along with some beams, will be tested by one of the leading technical schools during the coming autumn.

Will some of the professors suggest a practical method of accurately determining just what proportion of the imposed load on a test column is being taken by the imbedded steel. Very truly yours, "Engineer."

Toronto, Ont., June 7, 1906.

A Threatened Change in the Channel of the Missouri River at the Blair Bridge, Nebraska.

Sir: No doubt many of your readers will be interested as I have been in a dispatch published in to-day's New York "Times," dated at Blair, Neb., June 10 and reading as follows:

A thousand men with teams have been working for 48 hours to prevent the Missouri River from changing its course and leaving this town five miles west of the channel and the big Northwestern railroad bridge merely spanning dry land.

Nearly a week ago the Missouri began cutting into the Iowa bank rapidly. The Northwestern bridge train came at once and 200 men were put to work, making riprap and dumping stone and sandbags in the way of the span. Friday night 500 yards of dike were carried away, and Saturday morning the force was increased to 1,000 men.

There are several old channels in the valley here where the Missouri ran fifty years ago, and the stream has taken a sudden notion to go back into one of these dry beds. If it succeeds the loss will be very great.

The Blair bridge was designed by the late Geo. S. Morison, and built in 1884 by the Keystone Bridge Co., the construction and erection being in charge of the writer.

The resident engineer of this bridge was the late H. W. Parkhurst, whose portrait and biography were published in our issue of April 19. This bridge was designed to cross the Missouri River two miles from Blair, Neb., by three 330-ft. spans which were considered to provide ample flow for the river in flood and were sufficiently high above water to allow of the passage of the river steamers.

The site of the bridge was selected as the probable permanent location of the channel of the river, which was known to be very erratic in the changes of location of its channel. About 28 years earlier it had cut a channel near the foot of the bluffs forming the left side of the valley; again at a more recent date it cut a new channel through the prairies about in the center of the valley, and when this again closed naturally the river resumed its channel near the foot of the bluffs.

However, when the bridge was well under way and the high piers were nearly finished the river began to cut the left bank violently above the bridge site and it was deemed advisable to construct a stone dike above the bridge costing about $250,000, across the old slough still plainly visible, to guard against any possible damage to the bridge or the expensive earth embankment about 70 ft. high leading to it. To afford a passage for water which might possibly flow around the end of this dike at high flood, an open trestle was built in the line of the earth fill carrying the road bed.

It had been proposed to build the large trusses on temporary Howe trusses resting on pile piers at the center of each of the large spans and along the face of the stone piers of the bridge proper, rather than depend entirely upon falsework resting on piles in the river. It was necessary to keep one span clear for navigation and there was sufficient channel depth under the two westerly spans.

The work was commenced at the West span, and to the surprise of all the channel suddenly sanded up under it and soon became practically dry, as the water also fell slightly. Before the middle span was commenced the channel under it had shifted to the East span and there was so little water under the former that it was erected on pile trestles instead of on the Howe trusses.

This left one pair of Howe trusses unused on the bank, and the first pair was removed from under the West span to support the East span still to be built, as the water under it had become the main channel of the river.

About this time a rise occurred in the river, and the writer investigated its action above the bridge site. A great quantity of foam and sand was coming down stream, and the conditions gave all hands some concern. The Chief Engineer soon arrived to examine the progress of the bridge and also the action of the river. It had, however, become more quiet by the time he arrived, and it was concluded that the stone dike was able to hold its own. The spare Howe trusses came to the notice of the chief engineer, and as it was now plain that there would be no use for them in this bridge, the question as to what was to be done with them came up. The writer, talking with the Chief Engineer, made the apparently off-hand suggestion: "Why not leave the Howe trusses where they are; they may perhaps some day come in handy to replace the pile trestle in the gap in the earth embankment, should the river later on come around the stone dike and cut through to destroy the trestle, or else move them to Missouri Valley, where they would come in handy should the river take it in mind to leave Blair Crossing high and dry, and cut through its old channel on the west side of the valley."

This was more than the chief engineer could stand, and in his usual bluff way, after some puffing and grunting, he gave vent to criticism of the impertinence of some young engineers, who always were wiser than their seniors. The fact is, however, that before these trusses were removed, which was not undertaken that year, the river did wash out the trestle in the earth approach, and these trusses were utilized to replace it. If the above newspaper report is authentic, it is quite possible that the Missouri River may do now what the writer suggested 22 years ago, leave the Blair Crossing bridge on dry land by cutting a new channel on the other side of the valley.

Yours truly, Gus. C. Henning.

150 Nassau St., New York City, June 11, 1906.

TESTS OF THE STRENGTH AND FIREPROOF QUALITIES OF SAND-LIME BRICK.*

By Ira H. Woolson,† M. Am. Soc. M. E.

The very rapid and widespread growth of the sand-lime brick industry in the United States during the past two or three years has served to bring this new product before the building public with a suddenness that has caused astonishment and at the same time distrust. Surprise arose from the fact that such quantities of fine looking building material should be produced so rapidly from a sand bank, and doubt regarding its quality resulted from the fact that its method of manufacture was so radically new. Building superintendents and inspectors in all our large cities have been confronted with the problem of deciding whether to accept or reject this new product for use in their territory. The task has been, and is, far from a pleasant one for a conscientious man who desires to be true to his public trust and at the same time just to the man who persistently urges him to accept his new material as the equal of those whose durability has been proven by centuries of use.

This perplexing situation produced a demand for information regarding the physical properties of the new material which it was impossible to supply. A few isolated tests had been made upon it in different places, but as a rule the tests, as made public, were incomplete, and gave little information beyond the crushing strength. Data of this kind is of little use in determining the merits of bricks made at different factories and often by different processes. This was the condition of affairs which faced building superintendents and architects two years ago and in a large measure still exists although there have been several careful investigations made by different experimenters. In New York City we began to make numerous tests of various kinds upon sand-lime brick, but were at a loss how to interpret the results obtained. There were no specifications of quality for common clay bricks and we were in the embarrassing situation of having no standard by which to judge the merits of the new brick. As a consequence of this dilemma I was delegated by the Bureau of Buildings to make a full series of tests upon 15 varieties of common clay bricks selected from stock delivered at the buildings where they were to be used; this precaution of selection was taken to insure the samples being a fair average. The tests were made with much care and included transverse and crushing strength in normal condition. Absorption, and crushing wet after absorption, also freezing and fire tests were performed. Upon the data obtained from these tests and such information as had been gained from previous tests of sand-lime brick, the Bureau of Buildings framed a set of requirements that sand-lime brick must meet before they could be approved for use in the city. The report of these tests with the specifications, adopted by the Bureau of Buildings, was published in full in Engineering News of April 13, 1905, and in the May issue of the "Clay Worker." The tests developed several interesting features, one of which was, that the strength of the bricks tested was 20% to 50% lower than the figures given in text-books and handbooks.

For example: One of the best and most recent engineering handbooks gives the average modulus of rupture of good common clay brick as 600 lbs. per sq. in., and the compressive strength as 10,000 lbs. per sq. in. The average of 70 tests, upon good common brick as delivered in New York City at the present time, gave practically 500 lbs. for modulus of rupture and 4,000 lbs. for compression, or a drop of 16⅔% in transverse and 60% in compression. Subsequent tests upon several lots of like grade brick, part from New York and part from Philadelphia, confirm these figures. The actual data were as follows: Forty-nine specimens gave an average modulus of ruputre of 473 lbs., and 64 specimens in compression gave an average strength per sq. in. of 3,143 lbs. These are a little lower than the former results, but the proportion of pale burn was a little higher. I mention these facts to call attention to the desirability of a radical change in the figures on the strength of common brick as usually quoted. A marked characteristic of all these tests was a lack of uniformity in both the transverse and crushing strength. It was not unusual to find the strength of some samples two or three times that of their duplicates. This variation was more apparent in the transverse tests.

After the adoption of the specification for tests of sand-lime brick by the Bureau of Buildings of New York City, and the subsequent endorsement of the same by the Bureau of Philadelphia, a number of tests were undertaken for different manufacturers in an effort to pass the requirements. They met with varying success. At present three companies have received approval of their product. The wide variation in results obtained by different makers soon made it apparent that a systematic series of tests upon these bricks, similar to those already reported upon clay brick, together with a full size fire test, would be very useful in establishing the status of this new product.

Accordingly at the request of your executive committee I undertook to make the investigation suggested. This paper is simply a description of the tests applied and a discussion of the results obtained.

The method of making each test is explained in detail, so a full understanding may be had of the entire research. My excuse for this rather lengthy description is that I find many of the sand-lime brick manufacturers are new at this line of business and consequently not familiar with the general procedure and precautions necessary in making such tests to insure reliable results.

Seven varieties of sand-lime brick were shipped to me in lots of 300 to 800 by members of your association, and to these were added five kinds of clay bricks. Three lots of clay brick came from Philadelphia and two lots from the Hudson River district. These bricks were secured through the exertions of your efficient secretary, Mr. Duerr, and were intended to represent average stock of the different types of brick. Each variety of these bricks was designated by a letter, and throughout this paper reference to them will be made by letter only. For commercial reasons it would be unjust to give their trade name.

FIG. 2. VIEW OF FIRE TEST HOUSE SHOWING ARRANGEMENT OF BRICKS IN TEST WALL.

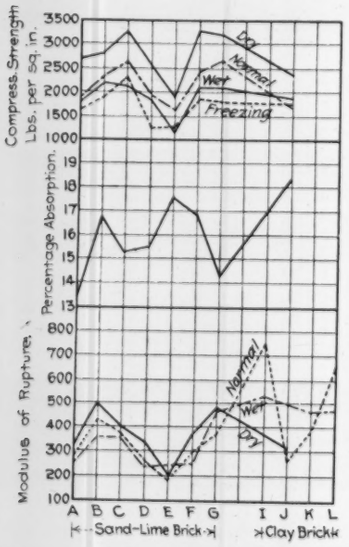

Fig. 1. Diagrams Showing Results of Tests of Sand-Lime Bricks.

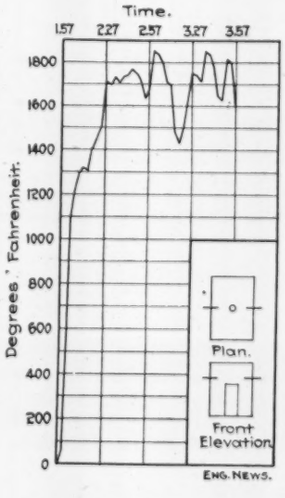

Fig. 3. Diagram Showing Range of Temperature in Fire Test.

*Paper presented at the Second Annual Meeting of the National Association of Manufacturers of Sand-Lime Products, held at Detroit, Mich., Dec. 5, 6 and 7, 1905.

†Adjunct Professor of Mechanical Engineering, Columbia University, New York City.

DESCRIPTION OF THE BRICK.

A. Bank sand carrying 2-10% of loam; not ground, but will all pass a 60 mesh screen; fine grain brick; hardened 10 hours at 120 lbs. pressure; 6% of lime.

B. Bank sand, very fine like molding sand; not ground; contains a little loam; fine grain brick; hardened 8 hours at 125 lbs. pressure; 10% of lime.

C. River sand with about 5% ground fine; no loam; appearance of brick indicated a medium coarse sand; hardened 7 hours at 150 lbs. pressure; 5% lime used.

D. River sand varying from very fine to coarse; no grinding done; contains small percentage of loam or clay; medium coarse grain brick; hardened 10 hours at 125 lbs. pressure; 4½% of lime.

E. River sand mixed with fine sand from separate deposit; contains small percentage of loam; coarse grain brick; hardened 10 hours at 120 lbs. to 125 lbs. pressure; in cylinder 7 hours; 4½% of lime used.

F. Pure river sand (99% silica) mixed with 5% ground silica and 5% lime; medium coarse grain brick; hardened 7 hours at 150 lbs. pressure contained numerous ½-in. quartz pebbles.

G. Bank sand ground; 35% passed 60 mesh sieve; contains 6 to 8% loam; fine grain brick; 8% lime used; hardened 10 hours at 125 lbs. pressure.

H. Bank sand ground; 8% passed 100 mesh sieve; contains about 7% loam; fine grain brick; 5½% of lime used and 5% cement; hardened 10 hours at 125 lbs. pressure.

I. Philadelphia Face Brick; smooth surface, fine grain and good quality.

I_2. Philadelphia Hard-burn Brick; rather coarse grain and rough on one side where cut.

The following brick were tested by fire only:

J. Philadelphia "Salmon" or "Pale" Brick; good quality of their grade.

K. Hudson River Medium to Hard-burned Brick; medium quality; considerable percentage distorted in burning forming bloated brick.

L. Hudson River Medium to Hard-burn; good average quality.

A large number of experimental tests made previous to this series demonstrated clearly that the percentage of moisture in a sand-lime brick controlled to a great extent the compressive strength of the brick as indicated by the testing machine. It was found that bricks dried to a constant weight before test developed an increase in strength over the same brick in the normal condition (that is, as received for test) of 20% to 50% as an average. An increase of 60% to 80% was not unusual, and the maximum obtained was 123%.

One lot of 12 samples tested some months ago for one of the companies who furnished brick for this present series showed an average increase in compressive strength dry, over the condition when received, of 58%. The brick in normal condition appeared to be fairly dry. This was a private investigation; the company has not been informed of the results and no publicity given the matter until now because fuller information was desired.

At the writer's suggestion, however, a clause was inserted in the specifications of the New York Building Bureau requiring that the "samples must be first thoroughly dried to constant weight." The majority of the tests made in the laboratory have been made upon the normal brick, for most investigations were begun before sufficient evidence had been acquired to warrant any change in the usual method of test.

A few tests were made to ascertain if repeated wettings and dryings increased the strength of the brick beyond that of one drying. The indication was that a slight increase was obtained in the compressive strength (no transverse tests were made), but the variation was not great. It was found, however, that brick dried and subsequently wet again lost the strength gained by the drying.

These experimental tests were made by breaking the brick transversely and crushing one-half normal and the other half perfectly dry. Some half dozen different methods of manufacture were tested and they all gave like evidence. These extraordinary results made it plain that data obtained from tests of different lots of brick as received in the laboratory was not comparable and very misleading. One lot of such brick might have been standing in a dry room for months and another in the open air. The former would give nearly its maximum strength, the latter far below it. The writer is fully convinced that the only way to test sand-lime brick for purposes of comparison is to first dry them to a constant weight at moderate heat (about 150° F.), weighing very closely to insure expulsion of all moisture; this usually takes four to six days.

Since most tests upon sand-lime brick have been made with no reference to their moisture content it was thought best in this series, to test the brick in both the normal and dry condition. The variation, though not nearly so wide as many previously obtained, is still quite conclusive.

It is recognized that perfectly dry brick are in an abnormal condition, but the method eliminates the variation due to moisture and brings all to a common basis for comparison. The strength values obtained from such tests will be somewhat fictitious, and might cause a modification of the allowable factor of safety, but it is not clear how these objections may be avoided.

To ascertain as far as possible the physical properties of the brick under all conditions to which it would naturally be subjected the following tests were made: (1) Transverse and crushing strengths in normal, dry and wet condition; also after freezing and fire tests. (2) Total absorption and rate of absorption, including tendency to discolor. (3) Specific gravity and weight per cubic foot. (4) Determination of moisture in normal brick. (5) Resistance to freezing. (6) Resistance to fire.

It is unsafe to predict the strength of brick or concrete upon two or three tests, since the natural variation in the product might give very misleading information. To avoid error of this kind consistent with the volume of the work, the majority of tests were made in lots of 10 each; freezing and absorption tests with strength tests afterwards were made in lots of five each. As far as possible the different tests were made upon halves of the same brick. This plan gives a more satisfactory comparison of results than would be otherwise obtained.

METHOD OF TESTING.

TRANSVERSE TEST.—The bricks were supported on well rounded knife-edge supports 7 ins. apart, care being taken to insure an even bearing on each support, thus avoiding twisting stresses. The load was applied at the middle

TABLE I.—SHOWING RESULTS OF CRUSHING AND TRANSVERSE STRENGTH TESTS OF SAND-LIME AND CLAY BRICKS.

		NORMAL CONDITION				DRIED TO CONSTANT WEIGHT				
SERIES LETTER	BRICK NUMBER	TRANSVERSE BREAKING LOAD IN POUNDS	TRANSVERSE MODULUS OF RUPTURE	REMARKS	COMPRESSION POUNDS PER SQ. INCH	BRICK NUMBER	TRANSVERSE BREAKING LOAD IN POUNDS	TRANSVERSE MODULUS OF RUPTURE	REMARKS	COMPRESSION POUNDS PER SQ. INCH
A	1	760	345		2100	11	650	260		2698
	2	530	257		1676	12	950	405		3197
	3	710	324		2151	13	860	367		2742
	4	630	284		1863	14	700	297	LAMINATION CRACK ALONG SIDE OF SPEC.	3050
	5	620	286		1883	15	590	265	VERT CRACK IN SPEC 1" OFF CENTER, IN	2527
	6	520	250		1575	16	800	347	WHICH RUPTURE OCCURRED	2507
	7	340	164		1742	17	620	271		2088
	8	790	356		2112	18	680	286		2781
	9	360	166		1556	19	760	324		2643
	10	690	308	LARGE PEBBLE IN ONE END OF SPECIMEN	1968	20	850	360		2421
	AV		272	AVERAGE	1873			320	AVERAGE	2604
B	1	880	405		2465	11	1100	514		2964
	2	930	433		2699	12	1070	483	LAMINATION CRACK IN CENTER	2206
	3	1230	528		2206	13	970	449		2825
	4	1010	465		2195	14	1160	525	" " NEAR BOTTOM	3001
	5	1010	460		2358	15	1210	546		2781
	6	1030	470		2290	16	1080	492		2627
	7	600	280		1944	17	980	456		2906
	8	870	401		2092	18	1040	479		2904
	9	900	412		2457	19	1190	553		3098
	10	840	393		2178	20	1200	547		2828
	AV		424	AVERAGE	2300			508	AVERAGE	2776
C	1	640	350		2487	11	770	407		3465
	2	840	482		2563	12	700	389	LAMINATION CRACK, A SMALL PIECE OF WOOD	3901
	3	650	350		2857	13	870	448	AT FRACTURE.	3926
	4	650	352		2271	14	840	438	" " AT CENTER	3192
	5	670	356		2539	15	680	340		3351
	6	650	326		2482	16	840	425		2803
	7	770	398		2892	17	760	396		2654
	8	770	403		2557	18	790	413		2745
	9	800	423		2862	19	840	450		3480
	10	840	443		2738	20	760	390		2902
	AV		377	AVERAGE	2571			406	AVERAGE	3240
D	1	490	252		1482	11	660	318		2436
	2	690	370		2344	12	970	494		2721
	3	630	303		2159	13	460	242		1740
	4	590	300		1950	14	730	373		2791
	5	450	243		1436	15	430	242		1813
	6	490	257		1875	16	670	308		2405
	7	580	279		2599	17	930	418		2559
	8	490	253		1995	18	720	328		2720
	9	460	254		1985	19	650	323		2643
	10	330	165		1709	20	790	354		2984
	AV		262	AVERAGE	1913			354	AVERAGE	2476
E	1	420	200		1684	11	500	227		2279
	2	440	186		1606	12	430	203	SURFACE OF SPECIMEN SCORED, FILLED WITH	2065
	3	380	178		1522	13	400	182	FINE SAND	1864
	4	300	144		1550	14	390	183	" " " "	1661
	5	430	214	SPEC. SCORED ON TOP, LEVELED WITH SAND	1706	15	370	170		1412
	6	490	214	" " " " " "	1987	16	450	206	" " " " " "	2063
	7	470	214	" " " " " "	1591	17	400	187	" " " " " "	1775
	8	360	173	" " " " " "	1610	18	470	214	" " " " " "	1559
	9	340	162	" " " " " "	1412	19	430	210		1746
	10	410	205	BROKE 1" OFF CENTER	1714	20	560	174	" " " " " "	1998
	AV		190	AVERAGE	1618			197	AVERAGE	1870
F	1	560	294		2532	11	750	400		3001
	2	640	326		2690	12	810	410	4-½" TO ¾" STONES AT LOCATION OF FRACTURE	3261
	3	590	309		2665	13	740	388	8-½" STONES IN FRACTURE	3170
	4	640	333	BROKE 1" OFF CENTER	2758	14	720	368		3068
	5	460	248	" ½" " ¼" STONE IN FRAC SURFACE	2609	15	500	256	10-½" TO ¾" STONES " "	2264
	6	520	274		2241	16	660	350		3901
	7	520	280		2735	17	600	359		3513
	8	630	325		2552	18	690	364		2989
	9	560	304	BROKE 2" OFF CENTER	1820	19	670	354		3000
	10	590	318	½" STONE IN FRACTURE	2213	20	620	480		3578
	AV		301	AVERAGE	2460			370	AVERAGE	3270
G	1	590	319		2180	11	780	450		2942
	2	530	306		2578	12	740	421		2812
	3	860	460		4672	13	780	458		3001
	4	470	267		2137	14	810	478		3442
	5	980	594		4804	15	890	490		3020
	6	550	321		2039	16	1080	632		4220
	7	570	340	SPEC SPALLED FILLED WITH FINE SAND	2534	17	950	518		3950
	8	670	350	" " " " " "	2081	18	810	440		2604
	9	550	318	" " " " " "	1076	19	970	536		3517
	10	600	348		2291	20	1000	544		2906
	AV		365	AVERAGE	2669			494	AVERAGE	3190
		TESTS UPON CLAY BRICK.								
I	1	1990	930		5460					
	2	2010	953	¾" PEBBLE IN FRACTURE	4363					
	3	860	445	" " "	4056					
	4	1310	630	2-½" " "	4248					
	5	1540	733	BROKE 2" OFF CENTER	5604					
	AV		746	AVERAGE	4746					
J	1	550	272		1518	6	730	326		2290
	2	480	239	BROKE 1" OFF CENTER	2103	7	570	271		2646
	3	300	144		1708	8	600	280		2703
	4	400	240		1198	9	760	348		1782
	5	550	256	LARGE AIR HOLE IN SPEC. BROKE 2" OFF CENTER	1651	10	550	256		2555
	AV		230	AVERAGE	1685			296	AVERAGE	2567
K	1	1130	668		2536					
	2	630	378	SHELLY CENTER	2902					
	3	640	368	¾" PEBBLE IN FRACTURE	3206					
	4	220	124	" " "	2787					
	5	710	406	BROKE 1" OFF CENTER	3000					
	AV		868	AVERAGE	2886					
L	1	960	371		3426					
	2	1370	940		3376					
	3	1160	675		4778					
	4	1290	784		4109					
	5	540	322	DARK CENTER	3690					
	AV		632	AVERAGE	4713					

by a similar rounded edge. The modulus of rupture was calculated from the well-known formula

$$R = \frac{3\,W\,l}{2\,b\,h^2}$$

and serves to bring the transverse strength to a common standard for comparison, irrespective of variations in size of cross section. Over 90% of the bricks broke exactly in the middle. Those which broke off center had distinct lamination cracks in the middle of the bricks, and these were elements of weakness.

COMPRESSIVE TESTS.—Half bricks from the transverse tests were used. Sheets of heavy fibrous paper were inserted between the specimen and the adjustable compression plates of the machine, to insure an even bearing on the faces. It was not advisable to use plaster-of-paris as a bedding material because of the moisture. Table 1 gives the full data of all strength tests upon normal and dry bricks and shows the effect of the treatment upon each individual brick, also the average values. Series H was not tested because notches had been cut in the edges for identification and this ruined them for transverse tests so all the tests were omitted. The average per cent. increase in strength for each series of dried brick over their strength in normal condition was as follows:

	Modulus of rupture.	Compression.
A	15.0 per cent.	30.2
B	16.0 " "	17.1
C	7.1 " "	20.7
D	21.5 " "	22.3
E	3.5 " "	13.5
F	47.2 " "	24.8
G	26.2 " "	16.3
Average	19.5 " "	20.9
J	15.5 " "	30.9

J. was the only series of clay bricks so tested. It will be noted that although there were wide variations in values, in the sand-lime brick the averages of the two columns are strangely alike. The moisture content of two bricks in each series in normal condition was determined, and found to vary from 1% to 10% with an average of 5.9% for all. A determination of the moisture in 18 sand-lime bricks of different makes which came to the laboratory last year gave less than 1% as an average. A part of them were evidently selected specimens and had probably been dried for some time before being submitted for test.

ABSORPTION TEST.—The method employed for determining the amount of water the bricks would absorb was that advocated by the writer in the article already referred to and adopted by the New York Bureau of Buildings. It has proved very satisfactory.

Five half bricks were selected from those broken in the dry transverse test. These were immersed in water to a depth of about ½ in. Weighings were made and percentages calculated at 30 minutes, 4 hours and 48 hours. Experience has shown that a brick is practically saturated at the end of two days, and although it may in time absorb a slight increase in moisture, the amount is so small it may readily be neglected for comparative purposes.

The rate of absorption is an important factor, and this is clearly shown in the columns of percentages in Table II. In most cases a large part of the water was taken up during the first 30 minutes, but in two instances the rate was slow. As a class the rate of absorption in the sand-lime brick is not nearly so rapid as in common clay bricks.

Two samples of each series were allowed to become saturated, and were then set aside to indicate discoloration effects due to moisture. None of them were seriously discolored. The following conditions were noted:

A. Both had a slight yellow stain and one had a white powder on the edge, probably carbonate of lime.
B. Slight yellow and white discoloration on one edge.
C. Slight white powder on one brick—the other clean.
D. Same as C.
E. Slight yellow stain on one brick—the other clean.
F. Yellow stain on edges.
G. No discoloration.

After the last weighing for absorption the bricks were tested for compressive resistance. Comparing results with the other halves of the same bricks tested dry it was found they had all lost strengths in amounts varying from 16% to 57%, with an average loss of the whole series of 32.6%.

To ascertain the effect upon transverse strength due to moisture, five whole bricks of each kind were saturated and then tested. The results are given in the first half of Table III.

In general, the transverse strength of the sand-lime brick wet, compared with the transverse strength dry, gives practically the same reduction as in the compression tests, the loss varying from 20% to 50%, but there were a few cases where the transverse strength wet exceeded the dry, and one whole series (E) exhibited this peculiarity. These bricks are marked with an * in the table. In two of the clay brick series the same condition was found; the reason for this reversal of the general rule is not apparent.

FREEZING TEST.—Half bricks from the normal transverse tests were used. They were first soaked in water for five days, then carefully weighed and placed in a refrigerating room and frozen throughout; after which they were thoroughly thawed in water at a temperature of about 120° F. The periods for freezing were usually 23 hours, with about one hour for thawing. Occasionally the freezing would be allowed to continue for 47 hours, and in a few cases, to expedite the test, only eight hours elapsed between thawings. However, as the temperatures were low the bricks were usually completely frozen in a few hours. The total number of freezings and thawings for each series was 20. Thermometer registered practically zero throughout the whole test.

After the last thawing the bricks were weighed and then tested for compressive strength. The loss by weight was insignificant, in fact, most of them showed a very slight increase rather than loss; this was probably due to increased absorption. So far as the appearance went, the freezing had no deteriorating effects, but the subsequent tests for compression while wet showed a decided weakness. How much of this was attributable to the effect of freezings, and how much to the presence of water alone, is uncertain.

The writer made a few tests on three kinds of sand-lime brick two years ago, in which the specimens were dried after the freezing tests before compressing, and these showed an increase in strength. He plans to investigate this subject further and ascertain whether the loss in strength is really due to the freezing effect; also how many freezings are necessary to disintegrate a brick. Thus far out of nearly 100 tests on sand-lime brick not one has been badly affected by 20 freezings and thawings.

In the fire test different varieties of clay brick were tested in parallel with the sand-lime brick. The strength of these bricks was determined in normal condition, but circumstances prevented a complete series test upon any except the "Philadelphia Salmon." The others were practically duplicates of the series published in Engineering News and Clay Worker, from which all the properties of these clay bricks can be obtained, except any effect that might occur from drying to constant weight. Whether or not there is any marked increase in strength in these brick due to drying is a subject for subsequent investigation. One would not expect the same variation in well-burned brick as in sand-lime brick, yet the tests upon the porous "salmon" brick gave widely different results.

The curves in Fig. 1 were plotted from the average values of all the tests and show the relation of the different tests for each series. They indicate also that there is a fairly uniform relation between the transverse and compressive strength. (This does not exist in common clay brick.) The compression and modulus of rupture curves are in general parallel and demonstrate that nearly all the varieties were affected the same way by the different tests.

A comparison of the absorption curve with the two sets of strength curves indicates that there is some relation between the strength of the brick and the total amount of water it is capable of absorbing. Thus, in series E, the absorption is highest and strength lowest. Similarly, in series G, absorption is low and strength high, but the other series do not show the relation so clearly, and some are contradictory.

As a lot the bricks were all low grade in strength and absorption; only one series (G) would pass the New York and Philadelphia Bureau of Building specifications.

The strength values were considerably below those of sand-lime brick which have come to our laboratory for test during the past two years. The general average of 163 bricks of all makes tested last year in transverse gave a modulus of rupture of 514 lbs., and the average of 177 compressive tests gave 3,190 lbs. per sq. in. The average absorption on 81 specimens was 12.0%.

The writer has made many private tests for some of the companies who furnished brick for this investigation, and the results were quite superior to those here recorded.

FIRE TESTS.

One of the principal objects of this investigation was to determine the fire resisting properties of these brick by a practical full size test in comparison with common clay brick. For this test the writer used the partition test house at his Fire Testing Station at Columbia University.

TABLE II.—SHOWING RESULTS OF FREEZING AND ABSORPTION TESTS OF SAND-LIME AND CLAY BRICKS.

	Number	General Effect	Freezing Tests: Loss in weight	Freezing Tests: Compressive strength after freezing in pounds per square inch	Freezing Tests: Reduction in strength by freezing	Absorption Tests: Number	Absorption Tests: Per cent absorption 30 min	4 hours	48 hours	Absorption Tests: Compressive strength wet pounds per square inch	Absorption Tests: % reduction in strength	Specific gravity	Weight per cu. foot
A	6	No apparent effect	1.6	1340	44.8	16	2.3	3.6	11.3	2100	16.2		
	7	" " "	1.01	1481	29.1	17	6.4	11.7	15.4	1987	24.0		
	8	" " "	.31	1281	30.8	18	3.1	4.3	11.8	1880	37.4	[illegible]	
	9	" " "	1.15	1401	47.2	19	2.3	6.4	12.8	1814	34.8	26 1881	113.0
	10	Two corners rounded	1.07	1676	24.8	20	3.1	11.4	13.2	1674	30.9	27 1815	112.9
		Average		1396	35.4		4.0	9.2	13.0	1811	27.5		
B	6	No apparent effect	0.13	2016	23.6	16	7.2	14.0	17.5	2081	22.7		
	7	Two edges much rounded	0.3*	1569	47.3	17	17.4	17.4	17.7	2108	29.4		
	8	No apparent effect	0.36	1647	28.6	18	17.4	17.5	17.6	2097	37.0		
	9	" " "	0.39	1909	33.6	19	9.3	7.0	13.1	2497	19.6	26 1693	103.6
	10	" " "	0.5*	1084	23.3	20	6.3	17.9	18.1	1971	30.5	27 1726	107.8
		Average		1612	34.3		9.0	14.9	16.9	2174	31.0		
C	6	No apparent effect	0.3*	2013	29.2	15	15.6	19.7	19.2	1951	30.5		
	7	" " "	1.4*	1334	15.1	17	15.3	19.6	19.9	1936	34.9		
	8	" " "	0.7*	2810	15.8	18	19.9	24.0	24.0	2178	10.9		
	9	" " "	0.4*	2147	26.2	19	11.2	19.9	24.5	2302	24.5	26 1616	113.3
	10	" " "	0.3*	2318	13.2	20	7.9	9.6	17.4	2162	13.3	27 1797	111.2
		Average		2265	21.8		14.2	14.9	23.3	2097	22.7		
D	6	No apparent effect	0.17	1761	26.8	16	6.3	19.6	19.8	1919	32.7		
	7	" " "	1.04	1240	30.5	17	9.4	17.8	19.4	1980	27.0		
	8	" " "	0.28	917	65.9	18	4.9	11.7	19.3	2101	19.4		
	9	Two spalls cracked on corner	1.0*	1105	34.2	19	7.5	15.4	19.4	1769	38.1	26 1640	102.9
	10	No apparent effect	0.04	813	74.7	20	4.1	12.8	14.7	2056	21.1	27 1838	114.0
		Average		1174	54.8		6.4	14.8	19.5	1953	27.7		
E	6	No apparent effect	0.4*	1613	21.9	16	14.0	14.2	15.0	1091	47.		
	7	Two edges badly wasted	0.3*	1396	19.6	17	13.8	14.1	14.3	1139	35.0		
	8	One face wetted	0.8*	970	37.5	18	14.6	14.5	14.9	1177	17.6		
	9	Two edges spalled, filled in less	0.6*	1002	42.6	19	13.5	13.5	13.8	1121	33.6	26 1760	110.5
	10	No apparent effect	0.3*	998	10.0	20	13.6	13.6	14.1	1015	49.5	27 1768	111.6
		Average		1197	30.3		13.5	13.4	13.5	1108	36.8		
F	6	No apparent effect	0.3*	1488	30.5	16	9.3	19.0	14.5	2102	28.8		
	7	" " "	0.58	2010	29.1	17	9.0	14.5	15.1	1746	46.7		
	8	" " "	0.02	1964	34.8	18	11.6	14.7	15.2	1880	37.5		
	9	" " "	0.33	2091	46.5	19	7.7	10.5	13.0	2178	42.0	26 1815	113.5
	10	" " "	0.33	1746	31.1	20	9.6	14.0	14.5	2500	38.4	27 1765	111.0
		Average		1891			9.7	14.3	14.8	2081	40.0		
G	6	No apparent effect	0.36	2014	36.4	16	4.4	6.5	15.2	2916	26.9		
	7	" " "	0.47	1727	31.2	17	8.6	11.	13.1	2611	43.5		
	8	" " "	0.01	1956	41.6	18	5.4	11.3	13.6	1949	31.3		
	9	" " "	0.02	1472	37.1	19	5.7	12.4	13.2	2094	36.0	26 1883	113.4
	10	" " "	1.01	1971	36.6	20	8.1	9.3	13.5	2084	19.1	27 1850	113.7
		Average		1759	47.2		6.3	9.1	14.2	2133	33.6		
		Tests upon Clay Bricks											
I												[illegible]	
												26 1855	114.7
												27 1850	113.0
J	1		0.5	2030	11.7	6	14.9	17.3	18.2	2145			
	2		0.9	1520	41.4	7	19.1	19.3	20.7	1240			
	3		0.2	1443	42.1	8	19.3	19.7	19.0	1218			
	4		0.7	2452	10.3	9	15.3	17.7	18.2	2470		26	
	5		0.1	1170	52.4	10	19.3	19.7	19.5	1451		27	
		Average		1714	23.0		16.6	17.4	18.3	1705			
K													
												26 1771	110.6
												27 1850	115.2
L													
												26 1881	114.0
												27 1881	113.4

TABLE III.—SHOWING RESULTS OF [illegible] AND DRY BRICKS AND ON BRI[illegible] FROM WALL TESTED BY FIRE.

Series letter.	Number of specimens averaged.	Modulus of rupture wet.	% reduction in modulus.	Miscellaneous Tests: Number of specimens averaged.	Miscellaneous Tests: Modulus of rupture after fire test.	Compression strength after fire test, pounds per square inch.
A	5	248	21.3	....	17	1807
B	5	349	51.4	3	57	2814
C	5	345	11.9	2	20	2373
D	5	241	21.2		32	2068
E	5	243*	25.3*	2	24	1088
F	2	259	19.6	2	27	2051
G	5	485	0.9	2	37	4885
			Clay Brick.			
I	5	528	17.1	....	140	3132
J	....	....	....	2	80	1825
K	5	458	63.8*	2	72	2192
L	5	462	19.4	2	108	3550

This h[illegible] is 14 ft. 6 ins. x 9 ft. 6 ins. on the outside, and cons[illegible] of reinforced concrete walls and roof, while the side [illegible]lls are removable. The floor of the building is a gr[illegible] upon which the fire is built and suitable draft op[illegible]gs and chimneys are provided. The sides were b[illegible] in as 8-in. walls with sand-lime brick for one, an[illegible]mmon brick for the other. The work was done by [illegible]gular brick masons who were instructed to make th[illegible] wall a good average job—no better.

The b[illegible]s were laid in bands about 14 ins. wide. In order th[illegible] each variety of brick might be subjected to the same he[illegible] conditions as far as possible, only half of a band wa[illegible] laid on the same level in the wall. The other half wa[illegible] placed in some other position. This arrangement of [illegible]e bands is shown in Fig. 2, where each series is outlin[illegible]d and marked by its letter. These are photographs t[illegible]ken of the outside walls before the test. In a few i[illegible]ances there were not sufficient brick to lay the whole [illegible]ortion of the wall. In such cases the inside course of bricks next the fire was kept true to name, and the outside, where unimportant, was filled up with some other variety.

It was also decided to test the merits of lime vs. cement mortars along with the brick. For this purpose half of each wall was laid with the different mortars. These are clearly indicated in the photographs. The walls were 17 days old when tested.

PURPOSE OF THE TEST.—The purpose of the test was to determine the effect of a continuous fire against the walls for two hours, bringing the heat up gradually to 1700° F. during the first half hour and maintaining an average of 1700° during the remainder of the test. Then a 1⅛-in. stream of cold water to be thrown against the wall for three minutes at hydrant pressure, which at this location varies from 25 to 30 lbs.

TEMPERATURE.—The temperature of the fire was obtained by three electric pyrometer couples. One suspended through the center of the roof, hanging 8 ins. below the ceiling, and the other two inserted through the walls at the middle, about 2 ft. from the top, one through each wall. Temperatures were read from each couple every three minutes. The plotted curve for the middle couple is shown in Fig. 3. The temperature on the other points were practically the same as for this. The fuel was dry cord wood. Frequency of firing was governed by the temperature recorded.

To measure the heat transmitted through the walls by conduction a bare bulb thermometer was placed against the outside of each wall and covered with a box to prevent radiation. The rise in temperature on the sand-lime brick wall was 119° F. and on the clay brick wall 74° F. The moisture in the sand-lime brick was converted into steam and this aided in raising the heat.

WATER.—In applying the water through the door in the end of the building the stream was thrown back and forth over the whole surface of the walls as much as possible and not allowed to play continuously in one spot.

EFFECT OF THE TEST.—Several large cracks developed in both the sand-lime and the clay brick walls during the test. These were no worse in one wall than in the other and were expected, for all walls, whether brick or concrete, form these expansion cracks during a fire test. It was not apparent that the kind of mortar had any effect upon the tendency of the wall to crack.

A furious fire was maintained for the allotted time, at the expiration of which the water was applied in the regulation manner. With the exception of surface deterioration the walls were solid and in good condition. After they were cooled the inside course of each wall was cut through and specimens of each series secured for examination and test. This opening was made at the middle. It was about 3 ft. wide and extended nearly across the building vertically. It was very difficult to secure whole bricks owing to the extreme brittleness. We endeavored to secure two samples from each series for test without tearing down the whole wall and in most cases were successful.

REMARKS ON CONDITION OF EACH SERIES AFTER THE FIRE.

SAND-LIME BRICK.—A. Appeared in good condition in wall, but were found very soft and tender on removal.

B. Practically same as A. Two bricks were spalled off by water ⅛ in. deep.

C. Somewhat wasted by water, particularly along lamination crack at middle. Badly cracked on surface, but whole bricks could readily be obtained.

D. Surface washed away by water on about half the bricks. Bricks were tender and broke easily in several pieces. Difficult to get whole brick.

E. Surface badly washed by water to a depth of ⅛ to ½ in. Tender and easily broken.

F. These bricks contained many quartz pebbles ½ in. or more in diameter. These pebbles burst on the surface and tore away the brick. General appearance bad. Many cracks.

G. Surface little wasted by water, but brick in very good condition. Whole brick easily obtained. Few cracks.

H. Few cracks. Good condition.

CLAY BRICK.—I. Full of cracks. Very difficult to get whole brick.

I₂. Many pieces spalled off by water. Bricks very badly cracked in wall. Could not secure a whole brick. Poorest of clay bricks.

J. These "salmon" brick seemed to withstand the fire the best of the clay bricks. However a large percentage of them showed cracks.

K. Badly chipped and cracked. Whole brick very difficult to secure.

L. Same as K.

In general the bricks were affected by fire about half way through. They were all brittle and many of them tender when removed from the wall, with the sand-lime brick, if a brick broke the remainder had to be chiseled out like concrete, whereas, a clay brick under like conditions would chip out easily. The clay brick were so brittle and full of cracks that the wall could be broken down without trouble. The sand-lime bricks adhered to the mortar better, were cracked less, and were not so brittle. These conditions made their removal much more difficult. They will doubtless get harder as the water dries out of them.

The clay brick cracked and spalled; the sand-lime brick washed away on the surface and became tender. It was difficult to find a clay brick that was not cracked in two or more pieces as they laid in the wall, but there were many sand-lime bricks that were apparently free from cracks; however, they were very apt to break in prying out. The half bricks from the clay wall when struck with similar sand-lime brick would in most cases shatter first.

The samples taken from the wall were tested and the results are given in the second half of Table III.

The transverse strength was extremely low in all the brick, but the compressive strength was very much higher in proportion. The strength of the clay brick was a little superior to the sand-lime in transverse, but at best they were bad. No advantage was evident in compression.

SUBSEQUENT NOTE.

Since this paper was written a large part of both the walls submitted to the fire test, have been cut out, and it is my candid opinion that the sand-lime bricks were in much better condition than the clay bricks. This opinion is emphatically endorsed by the brick masons who did the work, also by others who examined the walls.

Your Secretary, Mr. Duerr, informs me that he has made a study of the strength data presented in this paper, in reference to the percentage of lime used in each variety of brick. He found the relative strength value of each kind of brick per one per cent. of lime, by dividing the different strength values given, by the per cent. of lime used. In this way he was able to eliminate many of the apparent variations, and explain the seeming inconsistencies.

As a result of his investigation, he found that the bricks made with lime carrying magnesia were considerably weaker per per cent. of lime used, than those in which a high calcium lime was employed. It was also evident that too much lime weakened the brick. The indications were that no benefits were derived from lime in excess of 6 to 8%.

A REINFORCED CONCRETE LOCOMOTIVE COALING STATION OF UNUSUAL CONSTRUCTION ON THE LEHIGH VALLEY RAILROAD.

By W. E. Phelps.*

Among several recent notable improvements which have been made by the Lehigh Valley Railroad a new concrete-steel locomotive coaling station at South Easton, Pa., presents some novel features.

A consideration of the governing conditions at this point is necessary to a full understanding of the reasons for the adoption of this particular type of plant. The station is designed to furnish coal to yard engines and engines going to or from the roundhouse. About one hundred such engines per day of 24 hours will be coaled. An arrangement of crossovers will permit through freight engines in either direction to cut off from their trains and take coal when necessary.

South Easton is perhaps the most congested point, in a traffic sense, along the line of the Lehigh Valley Railroad, and absolutely none of the then existing track room could be spared for the location of the new structure. On the north side of the main tracks was a very valuable canal property, and on the south side, close up to the tracks, was a high rock bluff, into which it was decided to excavate for the new structure.

Easton is a terminal for some classes of freight, and all passenger trains change engines there, while a large number of yard engines are used in the immediate vicinity. The passenger engines generally burn lump anthracite, while the freight and yard engines burn a mixture of small anthracite and bituminous coal. This question of mixing considerably more than half of the five or six hundred tons of coal used daily caused the decision in favor of the platform type of coaling plant, instead of a plant in which the coal is dumped from the pocket directly into the tender. The plan adopted was to use one-ton carts or barrows (shown in the large photograph) and dump alternate loads of anthracite and bituminous coal into the locomotive tenders. At the end of the coal pockets is a sand pocket equipped with a steam drying apparatus and capable of storing about 850 tons of damp sand.

In this connection attention is called to the sharpening of the curve over the sand bin, for the double purpose of giving increased capacity to the bin and to pull the track away from the edge of the rock, which, due to some rottenness,

*57 Lake Shore Building, Cleveland, Ohio.

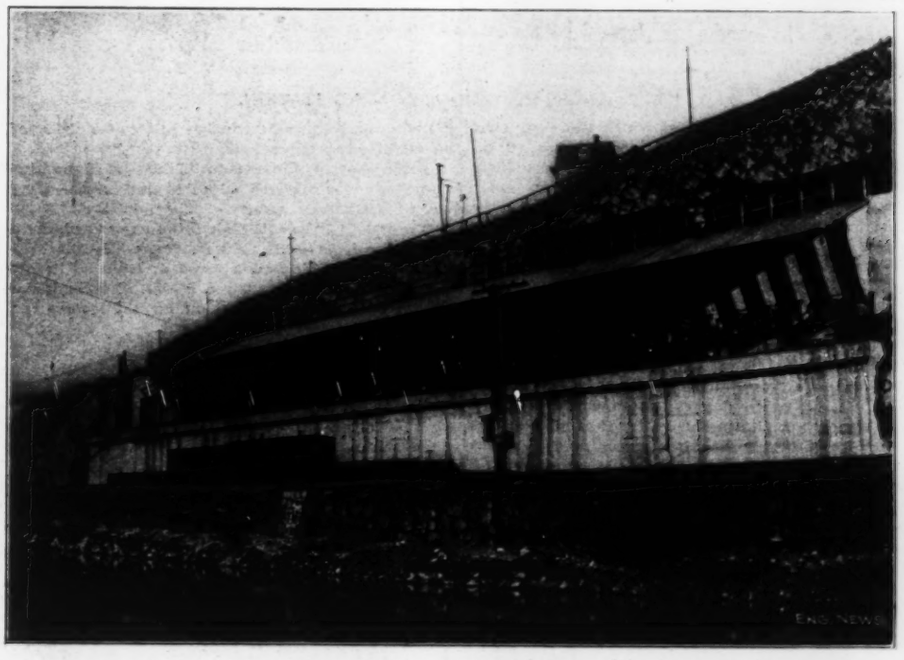

FIG. 1. GENERAL VIEW OF LOCOMOTIVE COALING STATION ON THE LEHIGH VALLEY R. R. AT SOUTH EASTON, PA.

had been cut back on a flatter slope than originally figured on. On this sharp curve it was considered impracticable to secure the rails to the I-beam girders with clips, as was done on the rest of the work, so the beams were set 7 ins. deeper in the piers, and ties were used to carry the rails.

The sectional view of the coaling pockets shows the method of construction and of the operation of the gates to the chutes, of which there are two to each pocket, thus allowing practically all of the coal to be drawn off. Each gate is provided with two operating levers, one on each side, pivoted near the top to allow of their free movement in a longitudinal direction as a man pushes a cart along under the chute, holding a lever in one hand. Each barrow is figured as holding one ton and engines are charged for coal on this basis. About 7,000 lin. ft. of ⅝-in. Ransome twisted steel bars were used in the reinforcement of these piers and the fronts of the pockets.

The dumping track on these pockets is from 40 to 41 ft. above the engine coaling track, and is on a 0.4% grade descending toward the west. Experience has shown, however, that this grade is not quite steep enough for the ready movement of the cars to spot them over the pockets by the men who do this work. The incline or approach track leading up to the top of the pocket is 1,375 ft. in length; 300 ft. on each end of this grade is taken up by vertical curves and 650 ft. of the remainder is on a 4.2% grade.

In addition to a large amount of excavation for this approach track, about 2,000 cu. yds. of dry retaining walls had to be built, varying in height from 4 ft. to 22 ft. Owing to the very limited space available for derricks, an old style hand "wrecking crane," or car, was rigged up with a small hoisting engine, and proved very useful; 90% of the walls less than 12 ft. high were built with this crane.

The difficulties attendant on the excavation and removal of the limestone rock, required in this work, were considerable. As previously stated, traffic at this point was very heavy, and had to be maintained uninterruptedly throughout the progress of the work. This work was within city limits, and great caution had to be observed in all blasting operations.

After two or three months' use of dynamite, "Joveite" was adopted as an explosive, and gave very satisfactory results.

Two small Ingersoll rock drills were used, drilling holes from 3 ft. to 9 ft. deep; air was supplied to the drills and a forge at from 80 lbs. to 120 lbs. pressure by three 9½-in. Westinghouse air-brake pumps mounted on an old locomotive. The average daily rate of drilling, per [illegible] was 31 ft. by day labor, but jumped to [illegible] ft. after "piece work" drilling was inst[illegible]. In this way more work was obtained for [illegible] than some quarries in the vicinity wer[illegible] ing.

The plans for this structure were p[illegible] by the writer, under the direction of M[illegible] Kenly, Division Engineer.

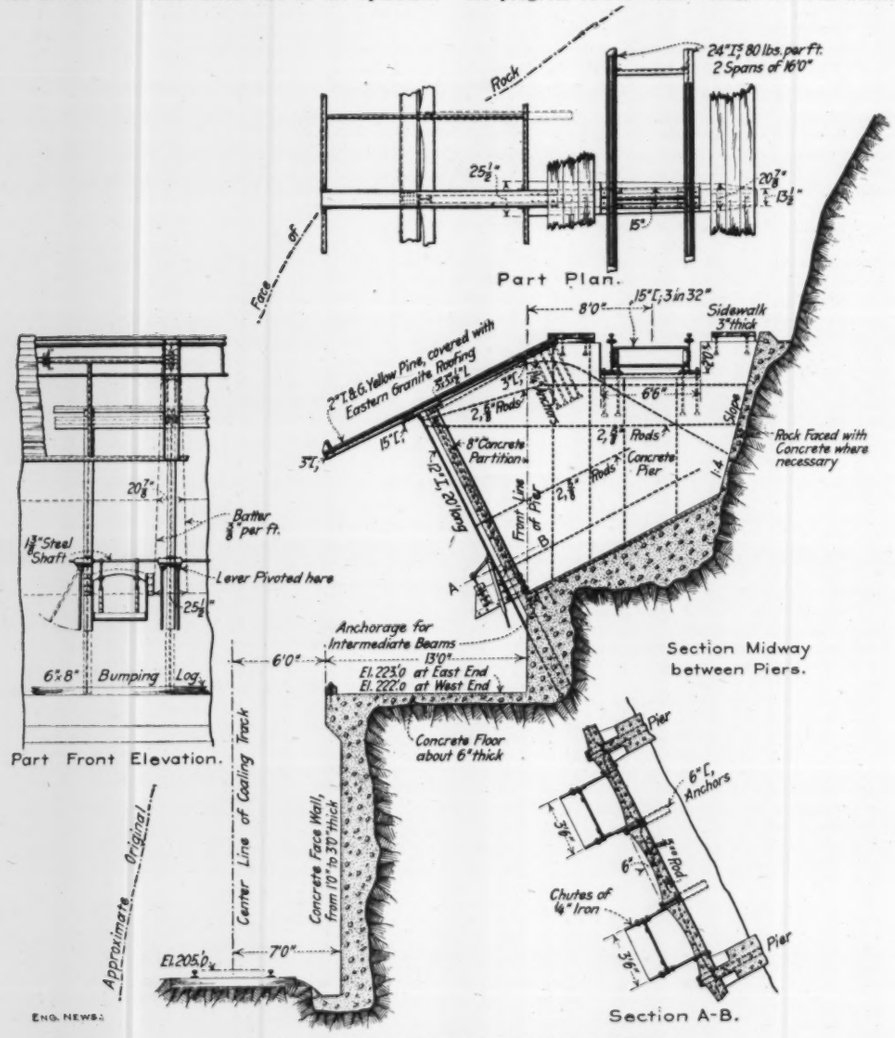

FIG. 2. CROSS-SECTION OF COALING STATION.

THE ROAD DRAG FOR IMPROVING EARTH [illegible]ADS.*

Any method for the improvement of earth r[illegible] which is simple, effective and inexpensive to operate [illegible] worthy of all the attention that can be given to it. [illegible] road dragging is such a method. Road drags have [illegible] known and used spasmodically for many years, but [illegible] mained for Mr. D. Ward King, of Missouri, to show by [illegible] sistent demonstrations the wide application and pra[illegible]al importance of the road drag.

Thousands of miles of mud roads can be be[illegible]ed materially by following the directions for the simp[illegible] method as here given. It will, no doubt, be necessary to underdrain many sections of road which may be dr[illegible]ed, but for immediate work this spring the most essential thing to obtain for the coming season is to have the surface of the roads reasonably smooth. This the road drag will accomplish. The State Highway Commission urges every township commissioner to have all the mud and clay roads in his township dragged.

The exact form or style of drag to be used is not the most essential part of road dragging. Almost any device will prove effective which will move a small amount of earth towards the middle of the road and at the same time smooth over the surface. As the whole theory and effectiveness of road dragging depends on the moving of but a small amount of earth at a time, it is important that no road drag be used which is of heavy design. In fact, the lighter and more simple the drag the more effective it usually is. A simple stick of timber or piece of steel rail has proved useful for this work; V-shaped drags have also been used, but seem to meet an objection, due to the fact of their heavy draught. Perhaps the most effective form of drag is that known as the "split-log drag," Fig. 1, or it may be made of two stout planks in place of the split log, as in Fig. 2. Oak or other heavy wood should not be used where it is possible to get a log of lighter wood. The log should be from 10 to 12 ins. diameter and about 9 ft. long. The holes in the front half of the log should be bored so that a slight slant forward is given to the lower part of the front face; the holes in the rear log are bored so that its flat face will be perpendicular to the sticks forming the connecting braces, which should be tapered at the ends so that they will fit snugly into the holes bored into the logs. The holes should not be less than 2 ins. diameter. The ends of the cross sticks should be split and wedges driven so as to secure the cross braces in place. The wedges should be driven crosswise of the grain of the log or plank so as not to split it. A diagonal cross brace is placed between the logs at the leading end to stiffen the frame of the drag.

The distance from face to face of the two pieces should be about 3 ft. The lower front edge or toe of the drag should be protected by a strip of old wagon tire, or other piece of iron about ¼ × 3 ins. and about 4 ft. long. This strip of iron should be bolted to the front log and the heads of the bolts countersunk; it should not be carried the entire length of the front log.

Chains should be provided with which to haul the drag, arranged with a short and long hitch, as shown, so that the drag will travel at an angle of about 45° with the direction of the road. It will be noticed that the long hitch of the chain goes over the log around one of the cross pieces rather than through a hole in the front log.

*Abstract of Bulletin No. 1 of the Illinois State Highway Commission; A. N. Johnson, State Highway Engineer, Springfield, Ill.

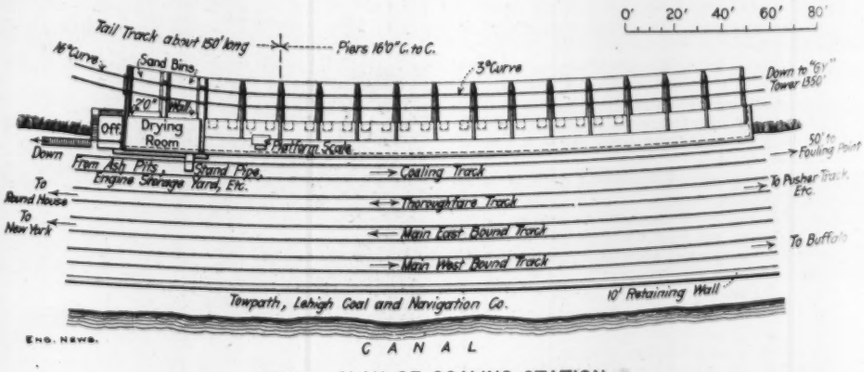

FIG 3. PLAN OF COALING STATION.

This allows the earth to slide unobstructedly along the front face of the drag. A platform of 1-in. boards (not shown) is laid upon the cross pieces for the driver to stand upon.

A modification of the split-log drag has been made by Mr. Edward Eisenberger, of Hudson, Ill., by which it is possible to incline the faces of the log so that they will slant either forward or backward, according as it is desired to have the drag cut deep or shallow. As the adjustment of the log is easily effected by the movement of a lever, it adds considerably to the ease with which it is possible to discharge the earth that may be collected in front of the drag at any particular point desired.

The objects to be attained by this method of road maintenance are to smooth the surface of the road when it is soft and muddy, and at the same time to move a small amount of moist earth to the center, thereby maintaining the crown of the road. The drag is not the implement to use to move large quantities of earth, nor does the maintenance of an earth road require the use of such an implement. A consideration of the theory of road dragging will help to make the use of the drag more fully understood.

Moist earth from the traveled portion of a road over a gumbo, clay or black prairie soil will be found practically impervious to water, as it has been worked or puddled by the action of wheels and hoofs. This puddled earth is usually full of holes and ruts, which are filled with water which cannot escape through the impervious soil. As long as the water remains the soil cannot dry out and the road is kept in a most uncomfortable if not

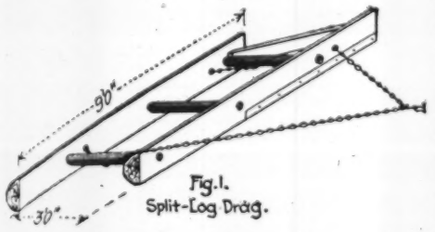

Fig.1. Split-Log Drag.

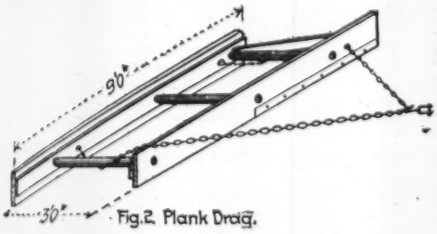

Fig.2. Plank Drag.

Drags for Improving Earth Roads.

impassable condition. This puddled earth when compressed and dried becomes extremely hard. On these two facts, the imperviousness of puddled earth and its hardness when dried, rests the theory of road dragging.

When the road drag is properly used it spreads out the layer of impervious soil over the surface of the road, filling up the ruts and hollows until a smooth surface is secured. As a small amount of material is always to be pushed to the center, a slightly rounded effect will be given to the road, which may be increased or decreased as desired by subsequent dragging. By forcing the mud into the hollows and ruts it is evident that the water must go out, which it does by running off to the side of the road. The drying out of the road is thus much facilitated and the road is made immediately firmer because the water is squeezed out. The effect of traffic over the road tends to press down and thoroughly compact the top of the road and each thin layer of puddled earth which the drag spreads over the surface every time it is used. After the first few draggings it will be noticed that the road is becoming constantly smoother and harder so that the effect of a rain is scarcely noticeable, the water running off the smooth hard surface which absorbs but little of it.

The following points are to be borne in mind in dragging a road:

1. Make a light drag, which is hauled over the road at an angle so that a small amount of earth is pushed to the center of the road.

2. Drive the team at a walk, and let the driver ride on the drag.

3. Begin at one side of the road or wheel track, returning on the opposite side.

4. Drag the road as soon after every rain as possible, but not when the mud is in such a condition as to stick to the drag. Do not drag a dry road.

5. Drag whenever possible at all seasons of the year. If a road is dragged immediately before a cold spell it will freeze in a smooth condition.

6. The width of traveled way to be maintained by the drag should be from 18 to 20 ft.; first drag a little more than the width of a single wheel track, then gradually increase until the desired width is obtained.

7. Always drag a little earth towards the center of the road until it is raised from 10 to 12 ins. above the edges of the traveled way. If the drag cuts in too much, shorten the hitch.

8. The amount of earth that the drag will carry along can be very considerably controlled by the driver, accordingly as he stands near the cutting end or away from it.

9. When the roads are first dragged after a very muddy spell the wagons should drive if possible to one side until the roadway has a chance to freeze or partially dry out.

10. The best results from dragging are obtained only by repeated applications. Constant attention is necessary to maintain an earth road in its best condition.

ROAD IMPROVEMENT WORK IN ILLINOIS.

In 1903 a special Good Roads Commission was created by the Illinois State Legislature to investigate and report upon the road conditions of the State and the means of improving country roads. This investigation included the available road-building materials, the drainage of roads, the employment of convict labor on the roads and the question of distributing the expense by systems of federal, State and country aid. This commission made its report at the legislative session of 1905. From the somewhat incomplete replies made to its various inquiries, the commission estimated that the State had about 100,000 miles of roads (exclusive of streets); 59 counties had 3,495 miles of road surfaced with stone, gravel, etc., but under the old road law (in force for 22 years) only 26¼ miles of "hard road" had been built in 13 counties. The commission advocated hard roads and recommended that the cost should be distributed as follows: 50% by the State, 25% by the county and 25% by the township. It further recommended the appointment of a permanent commission and a State highway engineer. With the completion of its report, the special commission passed out of existence. Its recommendations as to hard roads and State aid were not approved, but the Legislature passed a law creating a permanent State Highway Commission, and Governor Deneen has appointed Dr. Edmund J. James, President of the University of Illinois, as Chairman of the Commission. Mr. Arthur N. Johnson, Assoc. M. Am. Soc. C. E., has been appointed State Highway Engineer, and the commission has entered upon its work with a systematic and business-like way, and with due regard to the fact that engineering skill must play an important part in work of this kind. We give below some extracts from a statement given out by the Commission, and it is expressly stated that it is not the function or purpose of the commission to advocate "hard roads" or State aid in any form. This is done on account of the strong opposition previously aroused in the country districts (and especially the dirt-road districts) by former attempts (more or less political) to establish a system of hard road construction and State aid for hard roads.

Over 97% of the actual highway mileage of the State is earth road, and it will be our effort, therefore, to make such a study of the construction, care and improvement of these roads as will yield valuable results for the benefit of every portion of the State. In some portions of the State, the local authorities are constructing gravel and macadam roads. We shall offer to these sections such assistance in the way of advice as we may be able, by drawing up standard specifications, testing the quality of road-building material and finding deposits of material which may be of use in such road construction. In the last mentioned task we have been promised the aid of the State Geological Survey. We hope further to be of assistance in furnishing, on request, advice and specifications as to bridges, culverts, and other forms of structure necessary to highway maintenance. We shall aim to develop an engineering force of such character and training as will put at the disposal of the poorest road district in the State the best possible expert advice as to all matters falling within its jurisdiction. So that upon questions of grade, drainage, culvert and bridge construction the roadmasters of any district or the highway commissioners of any township or the authorities of any county may obtain, upon request, the best advice we can furnish.

The law makes it our duty to collect and publish full statistics relating to the highways of the State, and makes it the duty of local officials to give us the necessary information upon blanks furnished them for this purpose. We make an urgent appeal, therefore, to all road officials to assist us in the performance of this portion of our duty.

The law relating to the employment of convict labor in our State penitentiaries makes it the duty of the boards of management of these institutions to furnish to the Highway Commission such quantities of broken stone as it may call for—this stone to be of a size and quality suitable for use in highway construction. The State Highway Commission is authorized by law to distribute this stone among those road districts of the State asking for it free of all charge to these districts so far as the railways of the State are willing to carry such stone in return for similar stone to be used by them. The quantity of such stone available, is, of course, limited, and it will be distributed in accordance with general regulations intended to insure fairness in distribution among those communities asking for it. The penitentiaries are also required to manufacture tile suitable for road drainage, and road machinery, which will be distributed in the same way. But at present no penitentiary has actually installed a plant for manufacturing such tile. Due notice will be given to the road officers in the State when and where such tile and road machinery can be obtained.

It is further made the duty of the Highway Commission to undertake a careful and thorough examination into the best and cheapest method of highway construction adapted to the needs and conditions of the various portions of the State. Accordingly we shall begin a system of experimentation in the construction, maintenance and improvement of all classes of road which seem adapted to the peculiar conditions of any portion of the State. The co-operation of the highway department of the State University, in charge of Prof. Ira O. Baker, has been secured for this part of our work, and we shall hope to have some valuable results in course of time from this department of our undertaking.

AT A MEETING held at the Chemists' Club, New York City, May 28, the report of the Committee on the Commemoration of the Semi-Centennial of the Coal-Tar Industry was accepted and the recommendation adopted. The report follows:

The Semi-Centennial of the great discovery of Dr. W. H. Perkin shall be commemorated in New York City by a banquet and symposium on the development of the coal-tar industry, to be separately subscribed for by those who attend and by the presentation to Dr. Perkin of a personal token, and the establishment of a Perkin medal, to be awarded annually to an American chemist for distinguished work in the field of applied chemistry, and that at the same time there shall be secured the nucleus of a fund for the establishment at The Chemists' Club in New York City of a reference and circulating library, covering the entire field of theoretical and applied chemistry. It is estimated that the sum of $5,000 will be amply sufficient to cover the expenses of the personal token and the Perkin medal, while the sum of at least $50,000 will be necessary for placing the library on a permanent footing.

It was decided to hold the banquet and symposium on Oct. 6, subject to the approval of Dr. Perkin, who is to be invited as the guest of the Americans. The banquet will be held at Delmonico's, if the hall can be secured.

SINGLE-PHASE ALTERNATING CURRENT has been adopted by the Central Illinois Construction Co. for its additional eighty miles of track now under construction, consisting of two forty-mile lines, one connecting Bloomington and Peoria, the other lying between Springfield and Lincoln.

The present equipment of the Central Illinois Construction Co. is direct current, consisting of heavy suburban type cars equipped with four G. E. 75 HP. motors. There is now high tension distribution from the Riverton station at 13,200 volts, but this line is being changed to 33,000 volts, and the latter station will be supplemented by a second power-house located in Peoria with a common 33,000 volt transmission line connecting the two stations.

The apparatus for these extensions comprises 75 HP., AC compensated motor car equipments, made by the General Electric Co., together with necessary substations, overhead line material, generating station equipment, etc. Each car is equipped with four 75 HP. motors provided with Sprague-General Electric system of multiple unit control adapted for use on alternating current circuits, and are so arranged that they will permit tap control when running on alternating current, and series-parallel resistance control when running on direct current. In addition to the motors and control apparatus, complete AC-DC General Electric air compressors and straight air brake equipments will be installed, as well as head lights adapted for use on 25 cycle alternating current. The trolley will be of the pantograph type with rolling contact, raised and lowered by compressed air. For hauling freight a single-phase locomotive will be employed. This locomotive will be of the eight-wheel type, equipped with four General Electric 125 HP. compensated alternating current motors. The total weight

of the locomotive complete will be 50 tons, with a draw bar pull of 20,000 lbs. In common with the motor cars for passenger service, the locomotive will be equipped with the Sprague-General Electric multiple unit control for operation on both direct and alternating currents. It will also be supplied with complete air-brake equipment of the General Electric type, comprising an AC-DC motor-driven air compressor with the straight air brake apparatus.

To furnish additional power for this new rolling stock the present generating station at Riverton will be supplemented by a 2,000 KW., 33,000 volt Curtis steam turbine, furnishing current at 25 cycles, and the new power-house at Peoria will be equipped with two 2,000 KW., 33,000 volt Curtis turbines. The generator and high tension distribution system will be three-phase, and will feed the present rotary converter substations, and also the 80-mile section of track operating with alternating current.

The alternating current trolley will be of the well-known catenary type, suspended from brackets in the interurban sections and cross suspended through the small towns. Feeding this 3,300-volt trolley, there will be four AC. transformer substations, each substation containing two 200 KW., 33,000 to 3,300 volt, single-phase transformer with complete controlling high tension and low tension switchboard apparatus. These substations will be placed approximately 20 miles apart, and will be so arranged that trouble in any substation will automatically cut out that station without affecting operation on the rest of the line.

AN ELECTRICALLY OPERATED 1,000-TON concentrating, roasting and smelting plant is being constructed near Ely, Nevada, by the Nevada Consolidated Copper Company, of San Francisco, Cal. The new works, when completed, will constitute one of the most carefully equipped and thoroughly modern plants in the United States. The product from it will be electrolytic copper, the process of treatment consisting in the concentration of ores. One of the features of the new equipment will be the battery of six McDougal roasting furnaces, each 19 ft. 6 ins. high and 18 ft. in diameter. The main shafting for the entire group of six furnaces will be driven from a 20-HP. Allis-Chalmers induction motor, running at 850 r. p. m. The operator will be enabled to control the operation of each furnace from any one of three floors or stages about them. The list of concentrating machinery to be installed will include, among other appliances, six 6-ft. "Huntington" mills, specially heavy in design, of the Anaconda type, equipped with special step box and continuous shaft for three mills, dividing the six mills into two groups; also two heavy design Blake crushers; eight "Overstrom" tables, ninety-two vanners, and twenty-four "Richards" classifiers designed under the direction of the inventor, Prof. R. H. Richards, of the Massachusetts Institute of Technology. The engine equipment consists of two 22 and 48-in. × 48-in. compound condensing, heavy duty type engines; a 16-in. × 32-in. blowing engine delivering 6,000 cu. ft. of free air per minute. There is also two 800-KW Allis-Chalmers engine type alternators, two exciters and seven motors, ranging from 20 to 100 HP., for the operation of the various ore reducing devices, furnaces, etc.

PERSONALS.

Mr. E. K. Woodward, Principal Assistant Engineer of the Wabash R. R., has been appointed Chief Engineer of the Pere Marquette R. R., with offices at Detroit, Mich.

The following changes have taken place in the Reclamation Service: Mr. Luke C. Robertson has been appointed Assistant Engineer and assigned to the Uncompahgre Project, Colo.

Mr. E. M. Merriwether, Engineer of Maintenance of Way of the Wabash R. R., has been appointed Principal Assistant Engineer, succeeding Mr. E. K. Woodward.

Mr. J. D. Galloway, M. Am. Soc. C. E., has formed a partnership with Mr. John Galen Howard, Fellow American Institute of Architects, under the firm name of Howard & Galloway, and with offices at 604 Mission St., San Francisco, Cal.

Mr. George B. Sturgeon, who has been Assistant Engineer on the location and construction of the Waihu Canal, Sandwich Islands, has resigned, and removed to San Francisco, Cal., to engage in engineering work in connection with the rebuilding of that city. His temporary offices will be at 1858 Ellis St.

Messrs. G. R. Solomon and P. H. Norcross have formed a partnership, and opened a consulting engineering office at Atlanta, Ga. Mr. Solomon was formerly Assistant Engineer on the Rapid Transit Subway, New York City, while Mr. Norcross was recently associated with Westinghouse, Church, Kerr & Co. as Structural Engineer.

Mr. N. A. Christensen, the inventor of the Christensen air-brake system, has become associated with the Allis-Chalmers Co. as Consulting Engineer. Mr. Christensen is a Dane, and was educated in a polytechnic institute at Copenhagen, having previously been an apprentice in the city of Veile. While at Copenhagen he also engaged in practical work, thereby gaining a knowledge of steam engines, pumping engines, air compressors and lighthouse and signal service equipment, as well as ship-building and marine engineering. Later he removed to England, where, after serving as third engineer on an English merchantman, he obtained a position in the London office of a large Liverpool firm as designer. Here he designed the machinery and made the general plans for the new water-works at Calcutta, India. While employed at Darwen, Lancashire, as the head of the designing department of a company manufacturing Corliss engines, textile and paper making machinery, he constructed a new form of Corliss valve motion. He came to the United States in 1891 and secured employment with Fraser & Chalmers, of Chicago, as designer of Corliss engines.

While Mr. Christensen was in Chicago an accident occurred on the then new electric railway, known as the "Cicero & Proviso" system, at Oak Park, a suburb of Chicago, in which several persons were killed or injured. The accident was due to the inefficiency of the hand brake, and Mr. Christensen decided that a power brake was needed. The result was that he developed the scheme known as the Christensen system. In 1893 he entered the employ of the E. P. Allis Works, Milwaukee, Wis., and in 1894 developed his triple valve, quick-acting, automatic brake.

The Christensen Engineering Co. was organized at Milwaukee, Wis., early in the year 1897, for the manufacture of these inventions. In the fall of 1902 the scope of the business was broadened to include general electrical manufacture. Mr. Christensen was retired as General Superintendent, and a little later the company merged into a new corporation known as the National Electric Co. This company went into the hands of a receiver in the spring of 1905, and ten months later was sold at public auction to the Westinghouse Air Brake Co. This company surrendered all rights, title and interests to all the Christensen patented articles, as well as the claims of Mr. Christensen against the National Electrical Co., in the matter of unpaid royalties.

Negotiations have now been closed with Mr. Christensen whereby the Allis-Chalmers Co. get the control of the air-brake business, Mr. Christensen being retained by them as Consulting Engineer.

Obituary.

John B. McElfatrick died at his office in the Knickerbocker Building, New York City, May 5, of heart disease. Mr. McElfatrick was 77 years old and was a well-known theatrical architect, having designed some of the best theatres in New York City, Philadelphia, Brooklyn and other cities.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 18. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 21-23. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 26. Annual convention at Thousand Islands, N. Y. Secy., Chas. Warren Hunt, 220 West 57th St., New York, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 29 to July 4. Annual meeting at Ithaca, N. Y. Secy., M. S. Ketchum, University of Colorado, Boulder, Colo.

AMERICAN WATER-WORKS ASSOCIATION.
July 10 to 14, inclusive. Annual meeting at Boston, Mass. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 19 to 20. Semi-annual meeting at Chicago, Ill. Secy., W. M. Mackay, P. O. Box 1818, New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
July 23 to Aug. 4. Joint meeting with the Iron and Steel Institute at London. Secy., R. W. Raymond, New York City.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 15 to 17 Annual convention at New Haven, Conn. Secy., Frank P. Foster, Corning, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The sale was concluded last week of the society's house at 12 West 31st St., New York City; the price received was $120,000. It is expected that by December next the United Engineering Building will be ready for the society's occupancy.

AMERICAN SOCIETY FOR TESTING MATERIALS.—The ninth annual meeting of the society will be held at Atlantic City, N. J., June 21 to 23, with headquarters at Hotel Chalfonte.

The meeting opens Thursday, June 21, at 3 p. m., with a business session, the reading of miscellaneous papers, and the reports of committees. Friday there will be separate meetings by the sections on Iron and Steel and Concrete, and Preservative Castings, while today the sections on Metals and Fuels, Cements and Asphalt, Waterproofing and Testing will hold separate Miscellaneous Subjects will hold separate sessions. Some 55 papers or reports, which cover various phases of the above subjects, will be read before the convention. This is a much larger volume and variety of matter than has ever come before the annual meeting.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.—The Committee on the Relation of Traffic, which was appointed by the president of the 1905 convention, has sent an information blank to all the street and interurban railways of America, in order to obtain a full discussion of the various ways and means which are employed to stimulate traffic on their respective lines. The information thus obtained, together with other material upon this general subject, will be collated by the committee and will form the basis of the report which will be presented to the association at the 1906 convention, to be held at Columbus, Ohio, Oct. 15 to 19.

Likewise the Committee on Municipal Ownership, authorized at the same time, have sent out a sheet of questions in order to get the concensus of opinion of street and interurban railway corporations with reference to the question of municipal ownership. The committee will make a general investigation of this problem and report to the 1906 convention. Bernard V. Swenson, Secy., 30 Wall St., New York City.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.—The fourth congress of this association will be held in the halls of the Academy of Sciences, Brussels, Sept. 3 to 8, under the protectorship of King Leopold II, of Belgium. The convention will be opened Monday, Sept. 3, with a general meeting, welcoming of guests and a reception. The following days will be devoted to section meetings, inspection trips and addresses. During the congress a laboratory, showing the importance and advantages of new methods of testing materials, will be in operation in the academy. All papers will be sent to members of the association before the meeting, but none will be distributed at the Congress. The discussions will be held in three sections, Group A, Metals; Group B, Natural and artificial stones and their cements; Groups C and D, Other materials and miscellaneous, the sittings taking place at the same time. Only delegates of the authorities and corporations and members of the International Association will be admitted to the meetings, while ladies introduced by members may take part in the excursions and other entertainments. The price of membership tickets for the congress is $5 for gentlemen and $3 for ladies. Application for these tickets must be made before July 1, to Prof. E. Marburg, University of Pennsylvania, Philadelphia, Pa.

AIR-BRAKE ASSOCIATION.—The thirteenth annual convention of the association was held at Montreal, Canada, June 5 to 8, inclusive, with headquarters at Windsor Hotel. This is the first time the convention has been held in Canada and it was attended by about 400 railway men from all parts of the American continent.

The convention opened Tuesday morning with an address of welcome by Mayor Ekers and a response by President Carlton. Work of the Association was made the subject of addresses by Messrs. H. H. Vaughan and W. E. Fowler, which were followed by the annual presidential address by President Carlton, in which he discussed the recent developments of air-brake work, particularly in regard to the control of high speed trains. He strongly emphasized the necessity of air brake men making themselves thoroughly familiar with the new system of the electrical operation of air-brakes, which is now being adopted on many of the fast express trains in the States. This system, he said, had recently been adopted with success by the New York Central and Pennsylvania lines, and was being also used by many of the elevated and subway roads, owing to the much better control of fast trains secured by its use. A lengthy and detailed report was then read from the committee on "Recommended Practice," which thoroughly covered the whole system of handling air-brakes, and formulated a number of rules for their use and care. At two o'clock the delegates took a special train on the Canadian Pacific Ry. and visited the Angus shops of the company. A ball at Stanley Hall completed the day's program.

A number of technical papers were read at Wednesday morning's session, and at 1.15 p. m. the party left by special train over the Grand Trunk Ry. for Ottawa, where they spent the afternoon sightseeing and visiting the House of Parliament.

The papers read at the morning session were by Mr. Dusen, Resident Engineer, New York, of the Westinghouse Air Brake Company, on "Recent Improvements in Air-Brakes as Applied to Railway Work"; Mr. E. F. Wentworth, Inspector of the New York Air-Brake Company, described various improvements to his company's brake system, and Mr. C. C. Farmer, New York, Engineer of the Westinghouse Company, gave an address on "New Phases of the Triple Valve Brake."

The convention closed Friday with a business session.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, June 14, 1906.

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CORRESPONDENCE.

"The Cost of Competition."

Sir: The review of my "Cost of Competition," which appeared in the Supplement for May 17, was friendly enough, but the reviewer entirely missed the key-note of the book. He said that my arguments would all be knocked in the head by considerations of *human nature*, or that they omitted all such considerations. Of course they did. It was the prime and avowed topic of the book to discuss merely the forced relationships of individual human natures, *taking them as they now are*. For instance, engineering science consists in the use of materials such as we now have—impure iron, steel, brass, ets., none of them ideal—for our ends, by their association in more or less correct relationships. The question of the proper production of pure metals is the business of the metallurgist, rather than of the engineer. Yet is there no place for the engineer and his mechanics? Can he not easily so misplace his metals, in their use, as to lead to impact, friction, vibration, erosion, from too great concentration of pressure, etc., so that the efficiency of action falls to fifty, forty, thirty, or even zero per cent.? Or may he not, on the other hand, so use his metals, with care, patience and wisdom, that the efficiency rises to seventy, eighty, ninety or over per cent.?

This is the only question before the house. In our present industrial organization we have a most intricate structure for carrying out energy-transformations on an enormous scale; and yet its internal relationships have never been made the subject of study in the light of modern science, or of deliberate design based thereon. They have been inherited, haphazard, from a brutal and ignorant past. Only as the internal friction and impact periodically became too great to permit further operation at all has reform been instituted; and then chiefly by revolutionary surgery, under the stress of passion.

Here, in my "Cost of Competition," is a study of the internal efficiency of this industrial mechanism. Its pure, unnecessary friction and impact are revealed by mechanical analysis. Then the historical growth of that friction is discussed; it is shown how, since 1850, the efficiency of energy-transformation during *economic exchange only*, saying nothing about production, has fallen steadily from 70% in 1850 to 30% in 1900! Diagrams are given showing the increasing rate of drop in this inefficiency.

Here is all this done by an engineer for engineers, based upon the principles of the conservation of energy and of intensity-drop, upon the laws of motion and friction. Here is another engineer who reviews the work for engineers by saying. "It amounts to naught. Your materia's are poor, and your discussion will make them no better."

It is discouraging! Of course the materials are poor. How much can be done to make them better? Here we have schools and churches and libraries and missions growing as never before, based upon a science more complete than ever before; and still the inefficiency of a *wrong relationship* between citizens grows steadily and acceleratingly upon the community! Can your reviewer see no distinct problem here, and a problem appealing especially to engineers?

And does the simile end here? In mechanics, if a machine be poorly designed we note, even in inert metals, a resultant deterioration under stress and impact. Is not human nature to be expected to be more sensitive to its environment than is metal? Has the whole Second Part of my "Cost of Competition," showing how much, if not all, degeneration of human nature is the incidental *result*, and no primary cause whatever, of the wrong relationships imposed upon men and women, by the vigor of institutional laws and customs which are as old as slavery itself—as devilish as slavery, and as remediable, with a little courage and clear-headedness—has all this gone into one of your reviewer's ears and out the other?

Yours very truly,
Sidney A. Reeve, Consulting Engineer.

Worcester, Mass., May 31, 1906.

[Mr. Reeve's communication will convey to our readers a better idea of the spirit and purpose of his book than could any review, unless it were a long one, which included extracts from the volume. We therefore take pleasure in publishing it and in again bringing the volume to the attention of engineers and economists.—Ed.]

"Heat and Light from Municipal and Other Waste."

Sir: My attention has been called to the review of my book, "Heat and Light from Municipal and Other Waste," in your issue of May 17, and as I feel sure you do not desire to do an injustice to any book sent you for review, I call your attention to the unfairness and injustice of same.

That I am unbiased and unprejudiced in my opinion, I think can be clearly seen from the fact of my advocating both the reduction and incinerating methods of waste disposal, depending on the nature of the waste. See page 8, and also my report to the Sanitary Committee of the City Council of this city, pages 14, 15, and in other parts of the book. As much space is given to reports from cities and companies operating reduction plants, as to those operating incinerators, and every report is given "per haec verba," as received by me from the different city officials. For the city of St. Louis I am at present, and at the time this book was written, advocating the use of one reduction plant for the 23% of refuse capable of reduction in my opinion.

Of the 305 pages of this book, only 38 pages mention my inventions, all of which, except one, are in daily use; and then only in a descriptive way, without one word of commendation or disparagment of the work of others, and simply to bring out the requirements necessary for the proper incineration of refuse, and the operation of incinerating plants.

In reference to the franchises and legal forms, they are all taken in toto from forms which have stood the test of courts and have been approved by legal authorities whose opinion on legal subjects naturally are of more value than yours.

You state that a considerable number of errors are noted in the book and yet you fail to mention one which you can show to be an error. The report on the cost per capita of disposal in New York City is taken from the U. S. Census Report (see Bulletin No. 20, page 235). The report of the disposal of the refuse of Chicago is taken direct from the opinion delivered by the U. S. Supreme Court in the case of State of Missouri vs. State of Illinois and the Sanitary Drainage District. The report that the city and county of San Francisco receives 2% on the gross receipts for burning garbage, was taken from the official records of that city and from a personal letter to me from Mr. Andrea Sharboro, Secretary of the Sanitary Reduction Works of that city. You make the statement that some of the cities enumerated by me where the reduction process was a failure never had a reduction plant, except for experimental purposes, and in at least half of them you state reduction plants are in operation to-day. Please name me one giving satisfaction, or one having such a plant in operation, and which has not been declared a nuisance, or in litigation.

You say that my statement that a properly constructed incinerating plant can never become objectionable is absurd. With such a plant, there must be complete incineration and no odors and hence unobjectionable. A hundred of such plants are to-day in operation in England. Then why is this statement absurd? A fool can wreck the finest engine, but it is assumed no one would knowingly put him in charge of same. Should you read the book carefully you will find that I repeatedly state that skilled engineers and stokers must be in charge of incinerating plants.

Lastly, in reference to heating plants, I made the statement that there certainly should be profit sufficient during the heating season to satisfy any company. This is no superficial view of the subject. If you will look into the subject you will find that many heating plants pay more than expenses burning coal at $2 per ton, and half a dozen companies are making a 10% dividend paying 3½ cts. per 1,000 lbs. for exhaust steam. Then why not make handsome profits when their heat would cost nothing, as would be the case if operated in conjunction with incinerators? In fact, a company has been formed in this city, which proposes to offer both a bonus and large per cent. for such a franchise.

I am aware that my book is far from perfect, but so far as I can see you have failed to call attention to any real defect or error in same. I feel sure after verifying my above statements, you will make the proper amends.

Very truly yours,
Jos. G. Branch.

City Hall, St. Louis, Mo., May 22, 1906.

[Some of Mr. Branch's comments on the review of his book deal with matters of opinion and some with matters of fact. As to opinions we must, for the most part, let our readers choose between those expressed in the review, on the one hand, and in the book and the foregoing communication, on the other.

The reviewer did fail to state that in one or two places the author suggested the use of reduction plants, but this seemed over-balanced by the objections to such plants raised by him. As to the forms of franchises and contracts, the question raised was not one of legality, but rather of public policy.

The New York figures were correctly copied by Mr. Branch, but are, nevertheless, wrong, the Census Bulletin itself being in error. The Chicago figures cited refer to sewage, and not to garbage and the like, with which last, as our readers know, the famous Chicago-St. Louis controversy had nothing to do. The San Francisco figures are a percentage of gross receipts, and not a rebate, the city itself paying nothing to the company.

It is absurd to say that a properly constructed incinerating plant cannot be a nuisance for the very reason that Mr. Branch himself now suggests: because improper operation will make it so. It is hoped that central heating by means of heat from refuse destructors will prove practicable and profitable, but until more is known regarding heat utilization from American refuse it seems fair to raise a question as to the probabilities.—Ed.]

"Garbage Crematories in America."

Sir: In the review of my book, entitled "Garbage Crematories in America," published in the Supplement for May 17, you speak of certain opinions expressed by me relating to (1) the necessity for purifying the liquid wastes from garbage reduction plants before discharging them into bodies of water; (2) the necessity for determining that these liquids will not prove injurious to sewage purification works before discharging them into sewers, and (3) the value of "tankage," as "unwarranted." The opinions expressed by me were not given without consideration, although in a book purporting to deal with crematories I did not think it desirable to go into explanations regarding allied matters any further than was necessary to make the relations of the outlying subjects to that of cremation intelligible. Since you have called attention to the statements made by me, on matters quite aside from the main subject of my book, and not discussed at length therein, I trust that you will allow me to express more fully in your columns my attitude regarding the various processes of reduction, and the sanitary disposal of the waste liquids, as well as the value of the tankage for fertilizer.

I hold that the disposal of any liquid that is capable of putrefying when exposed to the air should be along the same lines as the disposal of sewage. The question of sewage disposal is a very complicated one; but I think that it is universally admitted that in the majority of places it is most advisable to remove from the sewage most of the organic matter so that it cannot putrefy subsequently. Most reduction systems heat the garbage in a closed receptacle, and subsequently separate the liquid from the solid portion, and from the liquid portion extract the grease. After the grease is extracted the liquid still contains a very large amount of organic matter in solution; a larger percentage than is found in solution in crude sewage. The liquid is, however, sterile, because of the heat to which it has been subjected. While it is not likely to be a source of infection to the stream into which it is discharged, it introduces into that stream a large quantity of organic matter that must be oxidized by the oxygen already in solution in the water of the stream, or it will putrefy and cause an offensive odor, as well as render the water unfit for use. I know of no use to which water is put in which the presence of a large quantity of organic matter is desirable.

As for the caution that I expressed against discharging the effluent from a reduction plant into a sewer leading to a sewage purification works already installed, I would

say that this caution is given because of experience that I have had with sewage purification plants in operation. Where a plant is designed to do certain work, it should not be called upon to do more work; and everybody who has had extended experience in the care of sewage purification works knows that a considerable increase in the quantity of sewage to be handled, or a considerable increase in the strength of the sewage, should not be made unless the plant is adapted to care for the increase. This is especially true of the more complicated systems where large quantities of sewage are cared for in a comparatively small area. My statement does not mean that the sewage works cannot be made to purify the effluent from a reduction works, provided it is designed with this object in view.

The point that ought to be recognized in this connection is that the disposal of the liquid resulting from the reduction processes should be complete, and the cost of this disposal should not be charged to the disposal of sewage, especially where the selection of a reduction plant is being considered in competition with other methods of disposal. In this connection I would add that there are quite a number of reduction systems now offered, and more being devised, and that some of them use chemicals to assist in the separation of the grease from the water, and that it should be definitely known that the particular chemicals employed in any specific case will not be injurious to the sewage works.

As for the value of the tankage, I acknowledge that the particular paragraph quoted by you would not cover the subject justly were it the object of the presentation to point out just when reduction is profitable. But the object in that connection is to point out, what I believe is the truth, that tankage cannot be relied upon to produce a valuable fertilizer. It is true that it is extensively used as a fertilizer "base." If any person interested in this subject will look up the meaning of this term "base" he will find that it means a material used to dilute a chemical product having a much higher fertilizing value. Some years ago I was interested in the problem of fertilizers, and had occasion to examine a number of the reports of the Department of Agriculture relating to the value of various products. One thing the tankage always does add to the fertilizer produced from it, and that is a most offensive and penetrating odor. Aside from the actual value of this material as measured by the quantity of useful matter that it communicates to the land, there is the more important problem (to the party who has it to sell) of marketing it at a profit. The facts are that the market value of it depends upon the nearness of it to a center of agriculture where this kind of fertilizing material is in demand, and that the value of it is almost invariably overstated by those interested in introducing reduction machinery. In very many localities it will not bring a price sufficient to pay for the handling. The grease, on the other hand, is sufficiently valuable to bring a fair price wherever it is produced, and in many plants proposed it must be relied on to produce the income upon which the plant must rely for the justification of its existence.

Far from being unfriendly to the reduction processes, I favor them wherever they can be shown not to be more expensive than other equally sanitary methods of garbage disposal. I do not think, however, that a reduction plant discharging its waste liquids into a sewer, where they must be purified at the expense of another branch of the municipal administration, should be compared as to cost of operation with a crematory where all the liquids are evaporated, and I do not think that at present small reduction plants can be operated at less cost to the community than small crematories that will do the work in an equally sanitary way. If you will refer to Chapter 10 of my book, entitled "Summary and Suggestions," you will note that I recommend municipalities having a population of over 40,000 persons to investigate the processes of reduction. If the price obtainable for the products of reduction were the same in all localities, the cost of operation uniform, and the amount of salable material per ton of garbage reduced not subject to wide variation, it would be possible to state with precision, in a general way, just how large a municipality must be to make reduction profitable under favorable conditions of haul; but these things vary within such wide limits that it seemed to me that the only course that can be pursued by one writing upon the general subject of crematories is to point out where the methods of disposal which he is not especially describing may be of interest to the reader.

Very truly yours,

Wm. Mayo Venable.

237 Broadway, New York City, May 25, 1906.

[The foregoing remarks would make a valuable addition to Mr. Venable's book and we hope he will include them in a future edition. Would it not have been well to have been more guarded in the original remarks on reduction if it was felt that the subject could be scarcely more than mentioned? In a book on cremation it would have been quite proper, of course, to omit all reference to other means of disposal.—Ed].

Railway Freight Yards and Terminals.

YARDS AND TERMINALS AND THEIR OPERATION.—By J. A. Droege, Division Superintendent, New York, New Haven & Hartford Ry. New York: The Railroad Gazette. Cloth; 6 × 9 ins.; pp. 285; 31 figures, mostly in the text. $2.50.

In reviewing this book it may be considered strictly without comparison with other works, as it takes up a subject hitherto dealt with mainly in the technical press and the proceedings of technical societies. This subject has of late years assumed such importance that it is quite time it should be dealt with in the extended manner which is possible only in a special publication. At the outset it may be said that the book under consideration is satisfactory in its comprehensiveness and completeness, as well as in its concise and readable treatment. The author is not afraid to make frequent and extended quotations or to give credit for them, and the quotations add to rather than detract from the character of the book, as they not only show what others have said and done, but also show that the author has not relied solely upon his own experience and opinions.

The book deals with practically two distinct subjects: (1) The design and equipment of yards; (2) the operation of yards. The latter subject has in the past been very largely disregarded by the engineer (even when having more or less work to do in connection with yards), as being quite out of his province. As a matter of fact, however, an intimate knowledge of the methods and conditions involved in yard work is absolutely essential for the engineer in the design of yards which will be efficient and economical in operation, and more especially for the large yards which are becoming such a distinctive feature of railway facilities.

The importance of terminals is first briefly discussed, but might have been made more conspicuous by some statistics of the actual work of large terminals, instead of the traffic statistics for the entire railway system of the country and the local passenger traffic statistics of New York City. In fact, it may be explained here that the book does not deal at all with passenger terminals. Two chapters are devoted to the important subject of yard design, with the numerous conditions and considerations involved, and it is shown that the present tendency is towards full cooperation of the engineering and operating departments in this matter. One interesting feature which may be noted is that with the enormous growth of traffic a single yard of sufficient capacity for the entire business may be too large for prompt and economical movements, and as a result of this some roads have established separate yards for general merchandise freight and for such special freight as coal; in this way each yard is kept within economic limits. The chapter on track details relates mainly to frogs and switches, and the question of hand or power operation of switches. The author expresses the opinion that for the ladder tracks of classification yards the most economical and practical plan is to operate the switches from a tower or central point by direct lever movements, not interlocked. Plants for supplying ice to refrigerator cars are given a short chapter, as are engine coaling stations and ashpits, but the two last are treated in other works and do not call for special notice. Mention may be made, however, of the author's suggestion to run the locomotives upon an elevated track and to discharge their ashes directly into metal cars which can be hauled in local freight trains and dumped at any required point, thus avoiding all shoveling and all ash-handling machinery.

The next subject discussed is that of methods of switching the cars for classification. Poling and summit switching are naturally given the most attention; tail switching is objectionable for large yards or large business, and gravity switching (without the use of an artificial summit) is rarely applicable. The author is inclined to prefer the poling system, on the ground of the facility with which cars can be started at varying speeds, according to the conditions of the weather and of the individual cars; another advantage is that the engine works at the of the train, so that the crew can see the men's signals clearly and can also see the of clear track on the body track upon whic car is to be sent. Mention is of course m the large Chicago clearing yard built for switching, but unfortunately this yard (w owned by independent interests) has neve used commercially, each railway preferr do its own work with its own facilities than to pay an outside company for perf this service. A large number of recent railway yards on the summit system are ever, described and illustrated.

Freight houses and team tracks or tea livery yards are given a separate chap which reference is made to freight storage or warehouses and to freight houses several floors in order to economize in area occupied. The chapter on freight p deep-water terminals consists mainly of t port on this subject made in 1903 by the and Terminals Committee of the American way Engineering & Maintenance of Way Association. Coal piers and coal storage plants are dealt with in a short chapter, but no mention is made of coal car dumping machines as used at shipping piers. The book contains no reference to the special facilities or arrangements required for serving grain elevators.

The chapters dealing with the operation of yards and with train service in relation to yard work occupy about 87 pages and commence with the intricate subject of the records of cars handled. To those of the uninitiated who have ever watched yard work it might seem a hopeless matter to attempt to keep such records, and a perusal of this chapter leads one to wonder how these voluminous records can be kept under the press of work and the adverse conditions of darkness and weather. Other interesting and important matters dealt with are as follows: (1) The management and discipline of the yard forces; (2) The duties and requirements of a yardmaster; (3) The loading of cars and general freight house and station work; and (4) The special requirements and methods involved in fast-freight train service. All these, however, we can only note in passing, although they relate very intimately to the details of yard operation. The making up of trains is a matter of a more technical character, involving problems of tractive power and the modern method of tonnage-rating instead of car-rating for trains; it also has to consider the arrangement of air-braked cars to comply with legal requirements. Nearly every road now has some formula for tonnage rating; some of these are simple and only approximate, others are complex and more difficult of application, but giving (theoretically at least) greater accuracy. In any case the formula must be used as a guide only, and variations made in the actual train tonnage to provide for varying conditions of engines, weather, etc.

It will be seen from the above review that the book is one for the engineer and the superintendent, for the yardmaster and for the student of or beginner in railway service. The comprehensive scope and concise treatment are worthy of note; and the same may be said also of the large clear type employed, and of the general satisfactory mechanical work upon the book.

PROPOSED PLANS FOR THE IMPROVEMENT OF THE CITY OF DENVER.—By Charles Mulford Robinson (Rochester, N. Y.) Denver, Colo.: Art Commission, City and County of Denver. Paper; 6 × 9 ins.; pp. 24; one diagram.

It is a pleasure to note another addition to the list of cities that are striving, through organizations of public spirited citizens, to improve their street plans and beautify their cities. In this Supplement for April 19 a somewhat similar report on Columbia, S. C., another State Capital, was noted. In the report before us the grouping of public buildings and the opening up of spaces in front of the capital building and some changes in parks and boulevards are the chief improvements suggested.

The Mechanical Equipment of Electric Power Stations.

Reviewed by Wm. Kent,* M. Am. Soc. M. E.

MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY.—A Treatise on the Theory and Practice of the Mechanical Equipment of Power Stations for Electricity Supply and for Electric Power and Traction. By E. Tremlett Carter, C. E., M. Inst. E. E., Fellow of the Physical Society of London, etc. Second Edition, revised in part by G. Thomas-Davies, Assoc. M. Inst. E. E. New York: D. Van Nostrand Co. London, Eng.: "The Electrician" Printing & Publishing Co., Ltd. Cloth; 5¼ × 8¼ ins.; pp. 672; 290 figures, mostly in the text. $5, net.

The first edition of this book was issued in 1898. In a brief preface to the second edition, the reviser says:

> Which only partly effected by the author the revision of this book for the present edition was interrupted by the physical weakness which, unfortunately, resulted in his death.

The work of the reviser was limited to practically rewriting six chapters and three of the appendices. He hopes that his work will result in giving the book a fresh lease of some usefulness and in keeping it alive to the memory of his late friend.

The book is essentially a compilation of the principles, theory and results of experiments on the mechanical engineering features of electrical power plants, with some illustrated descriptions of existing plants. After treating in the first chapter of the fundamental principles of mechanics, the author gives a few pages in the second chapter to details of the problem, which include the factors of idleness and of underloading and the character of power station load diagrams. The next ten chapters are devoted to fuels, thermodynamic principles, steam furnaces and boilers and the steam engine. This completes the first 350 pages of the book.

Part III. treats of gaseous and liquid fuels, gas producers and gas engines, and occupies 74 pages. Part IV. treats of water power plant in 55 pages. Part V. (38 pages) is devoted to belt and rope gearing, countershafts and couplings, pair-closed gearing, and gearing in relation to electric power, closing with a statement as to the probable extinction of gearing in stations. Part VI. comprises a chapter of 26 pages on steam power stations, and another of 32 pages on gas and water power stations. These chapters give illustrated descriptions of several British power stations. The appendices include one on Druitt Halpin's system of thermal storage, one on later developments of internal combustion prime movers and one on analyses of accounts of some gas and steam stations.

The work is thus seen to include many subjects which are usually treated in separate books. It is neither a text-book nor a work of reference but practically an encyclopaedic compilation, from various sources, of descriptions and data on mechanical engineering which are supposed to be of interest to the electrical engineer. It is difficult to say just what field of usefulness the book can have. The engineering student will find each of the subjects of this book treated in far better shape in numerous standard works, and the general reader who is not a student will find the book in many cases too difficult of comprehension for him. For instance, thermodynamic principles are treated in the old-fashioned method of the calculus, and entropy is defined as follows:

> Thus, the same mass of gas may be worked under an indefinite number of perfectly adiabiatic operations in succession, by successively varying some function of the initial intrinsic energy and the temperature. This function has been called by Clausius the entropy of the substance, whether gaseous or otherwise.

Some pages further on the newer method, that of the temperature-entropy diagram is given, but as only two pages are devoted to it the treatment is necessarily incomplete.

The author is not even a judicious compiler. In treating the subject of energy, on the second page of the book, instead of going back to the old-fashioned definitions of Rankine and his followers, he treats the subject in this manner:

> There are only two things in the material universe—energy and matter—or, some would say, energy and ether, making ether and matter one. Energy, however, is not strictly regarded as a *thing*, that is to say, as having separate existence in itself. Energy is a condition or set of conditions in matter; it is that condition in matter which enables the matter to exert force against any resisting force, and to overcome that resistance through a distance.

Thus, in the very paragraph in which he says there are only two things in the material universe, energy and matter, he is compelled to introduce two other things which are also in the material universe, namely, force and distance.

In discussing the system of units adopted in mechanical engineering, the author says:

> The unit of mass in this system is designed to correspond to the units of force and velocity, and is such that if a force of one pound acts on it for one second it will acquire a velocity of 1 ft. per sec. Inasmuch as the weight-force of a pound acting on its own mass alone will cause it to acquire a speed of 32.2 ft. per sec. at the end of one second (g), it will be evident that the unit of mass must be 32.2 times more massive than 1 lb., or will equal 32.2 lb.

This quotation shows that the author has obtained his ideas of mechanical engineering units from some of the recent books written by physicists rather than by mechanical engineers. A mechanical engineer never uses as the unit of mass 32.2 lbs. His unit is always the pound avoirdupois, which is also his unit of weight, whether the word "weight" is defined in the good old dictionary way as a measure of the quantity of matter or in the restricted way in which it is used by regular writers on physics, not engineers, as the amount of the attraction of gravitation on matter. In 99 cases out of 100 the engineer when he uses the word weight means the quantity of matter as determined by weighing it on a platform scale or on an even balance.

In treating of chimneys the author covers three pages, but what he has to say is entirely theoretical and is of practically no use in the actual design of a chimney. In treating of steam boiler efficiency the author makes some statements which appear to the present writer to be quite new—at least he has never seen them elsewhere. Thus:

> The steam boiler has the credit of being considered by engineers to be a very efficient appliance; but it requires only a little investigation on scientific lines to reveal the fact that this credit is entirely misplaced, and that the steam boiler is a most inefficient and wasteful adjunct to the power plant. . . .
>
> Only 20%, or 2,780 B. T. U., is wasted in radiation and other losses, and in developing the draft. Accordingly, it has been said that the thermal efficiency of a good boiler may be as high as 80%!
>
> The argument is specious, but utterly wrong. Of what use is it that the boiler should turn out 80% of the total heat of the fuel, when it turns it out in such a form that only a very small fraction of this percentage can possibly be utilized for doing work?
>
> Some writers have attributed the great inefficiency of steam plant to the engine, not to the boiler. That the boiler and not the engine is principally the culprit is evident from the fact that if we wish to cause a considerable rise of efficiency, we must improve the boiler; there is not much need to improve the engine.

As a sample of the style of the author the following, from the introduction to his chapter on Hydraulics, page 439 is quoted:

> It will be unnecessary here to pursue an inquiry into the action by which solar heat or soli-lunar tide raises water from any level to a higher level. We start with the fact of its being so raised, only staying to recognize that water per se has no energy virtue—its mass and the action of gravity on that mass are all that constitute the source of energy. The fluidity of the water and the ceaseless cyclic return which nature causes it to make to the higher level are, however, valuable factors in the practical utilization of gravitational energy. Otherwise we might erect gravity engines worked by any other falling mass—e. g., rock. The theory of gravitation engines, as applied to water motors, consists of a portion which will be independent of the special properties of water, and a portion which will include these special properties—of fluidity, viscosity or friction, incompressibility, etc.—in its subject matter.

In discussing the question of head, he says:

> The total head of any given mass is equal to the ratio of the gravitational energy of that mass divided by the weight of the mass; and it is found by determining the height through which, if that mass were raised, it would acquire an additional amount of potential energy equal to its gravitational energy due to the total head.

The above extracts are examples which are seen frequently throughout the book of the tendency of the author to treat the simplest kind of a mechanical subject in language which requires to be read several times by the ordinary reader before he can form a comprehension of just what it means.

The book contains a great quantity of useful facts concerning mechanical engineering, and if any engineer in an electric station is so unfortunate as not to have received an education in mechanical engineering or not to possess at least a few treatises on the several branches of that subject, this book may be useful in calling his attention to many of the principles and data of mechanical engineering, but it does not appear that the book can be of any special value to any other class of men. It may seem ungracious to criticize so severely the work of a dead author, but the reviewer ought to give his honest opinion, and he must say that the book is one of the kind that should not have passed beyond its first edition.

*Dean of College of Applied Science, Syracuse University, Syracuse, N. Y.

A Book for English Trade Schools.

EXPERIMENTS ON HOT WATER SYSTEMS.—By A. Sayers, Lecturer on Plumbing, Municipal Technical Institute, Belfast. With Prefatory Statement by F. C. Forth, A. R. C. Sc. I., Principal, Municipal Technical Institute, Belfast. (Revised and Reprinted from "The Plumber and Decorator.") London, England: Sanitary Publishing Co., Ltd. Belfast, Ireland: W. Erskine Mayne. Cloth; 5¼ × 8¾ ins.; pp. 168; numerous illustrations in the text. 3s., net; American price, $1.20.

This is a curious book. Most American engineers, judging the book by its title, would suppose it to be a book about hot water systems of house heating. Actually it relates entirely to the hot water piping in connection with the common range boiler. Now, why should anybody try experiments on so simple and everyday a piece of apparatus as the hot water piping from a range boiler? It is, under all ordinary circumstances serviceable and innocuous. Why not let it alone?

These experiments were not few in number. They number nearly thirty. They were not made, as one might suppose, by a journeyman plumber, to kill time—for which somebody else paid at union rates—but by the Lecturer on Plumbing in the Municipal Technical Institute of Belfast, Ireland. They were made in the Institute Workshops "during the years 1902, 1903 and 1904." The preface to the book, written by the Principal of the Municipal Technical Institute, states that he was "a constant and very interested observer of the experiments during their progress," and that "those more competent to judge of the practical aspect of the question that I am have stated that the book throws much light upon many hot water circulation problems hitherto very little understood."

Evidently the principal saw that the "Lecturer" was busy with his students doing things that had at least a practical aspect, and the Lecturer appears to have been one of those men who are imbued with a zeal for "research," no matter whether the object sought for is worth a picayune or not.

It is not worth time or space to criticise in detail the matter of the book, except as it throws an interesting sidelight on current British methods of instruction in Technical Institutes, or, as we should call them, trade schools. The book relates, of course, to British plumbing practice, which is so different from American, that even if an English plumber could learn something from this book, it is safe to say an American could not.

It is, we believe, generally accepted in this country that in order to teach a technical subject to an ordinary workman of limited education, and perhaps of limited mental ability, the whole subject must be presented in the simplest and plainest manner possible. The more we surround a subject with mystery and big words, and the more we harp on the difficulties and profound problems, the less likely is our student to acquire a practical working knowledge. We have compared these "experiments" with a condensed treatise on plumbing issued by an American correspondence school. The latter is direct, plain and brief, and appears to us well adapted to give the journeyman plumber a clear understanding of his work. The "Experiments," on the other hand, appear to us well calculated to lead the journeyman into hot water, and leave him bewildered as to how he came there or how to get out.

Electrical Books.

Reviewed by Henry H. Norris.*

ELECTRIC TRANSMISSION OF WATER POWER.—By Alton D. Adams, A. M., M. Am. Inst. E. E. New York: McGraw Publishing Co. Cloth; 6 x 9¼ ins.; pp. 335; 105 figures in the text. $3, net.

NOTES ON ELECTROCHEMISTRY.—By F. G. Wiechmann, Ph. D. New York: McGraw Publishing Co. Cloth; 5½ x 8¼ ins.; pp. 145. $2, net.

ELEMENTARY ELECTRICAL ENGINEERING. — Its Theory and Practice. A Class Book for Junior and Senior Students and Working Electricians. By J. H. Alexander, M. B., A. I. E. E., Author of "Model Engine Construction." London, Eng.: Crosby Lockwood & Son. New York: D. Van Nostrand Co. Cloth, 5 x 7½ ins.; pp. 208; 181 figures in the text. $2, net.

PRACTICAL ELECTRIC RAILWAY HAND-BOOK.—By Albert B. Herrick, Consulting Electric Railway Engineer. Second Edition, Revised and Corrected. New York: McGraw Publishing Co. Leather; 4½ x 6¾ ins.; pp. 460; 329 figures in the text. $3, net.

The electrical transmission of power affords one of the most attractive fields for engineers and inventors. This results from the possibility of transforming mechanical power into high tension electrical form with comparatively small loss. Such high tension power can be transmitted to any distance, the commercial limit being set only by the cost of erecting and maintaining the pole line. Transmission lines are being extended in all directions from the principal water power sites in this country and abroad, and there appears to be little difficulty in disposing of the transmitted energy. This is needed for railway and lighting purposes everywhere, and when electric energy from a transmission line can be bought at a reasonable price it readily displaces its steam generated rival. The fact that engineers are studying the subject is indicated by the rapidly increasing quantity of literature devoted to it, one publisher alone having put out four volumes within a few months. The meetings of engineering societies are frequently occupied in important discussions dealing with the several phases of the transmission problem.

Among the recent books, that of Mr. Adams is one of the most readable and compact. It may be characterized as a brief résumé of the present practice in transmission line construction, with some reference to the design and arrangement of water power plants. It is practically all devoted to descriptive matter which is introduced to illustrate certain fundamental principles. The author has arranged the material systematically under a number of topics, the first treating of the importance and utility of water powers and giving a list of the present water power transmission systems, with the names of the cities in which the energy is delivered. The prophecy is made that within the next ten years the greater part of the electrical supply on this continent will be drawn from water power. Immediately following the introductory chapters is a discussion of the cost of conductors and the limits to which power may be economically transmitted, these two matters being very closely allied. The location and arrangement of water power stations are next treated, and a number of interesting examples of modern plants are employed to emphasize the statements. The illustrations in this section are particularly interesting, as they include a number of typical stations, in course of erection and in completed form. A chapter on design is inserted at this point, and it forms a summary of the lessons taught by a study of the different installations. In connection with the power plant some space is given to the component machines and other devices of which it is composed. Alternators, transformers, switchboards and accessories are included under this head. Then follows a chapter on regulation of electrical pressure in the transmission system, which subject serves to connect the two main sections of the book, the first of which is mainly devoted to the power plant, while the latter covers the problem of the transmission line.

The latter half of the volume is devoted to the construction and operation of the transmission line. Starting at the station the author first shows how the line is protected from lightning and from accidental crossing with other lines. He then discusses the relative merits of the different materials used as line conductors and indicates the principles to be followed in selecting conductors from the standpoint of power losses in the circuit. This naturally leads to a brief statement of the reasons for selecting particular arrangements of circuits for given cases and typical lines are cited to give force to the arguments advanced. The pole line and its recent competitor, the steel tower line, are treated in an ample manner and such important details as insulators and pins are given deserved prominence.

The book occupies the same general field as Bell's Electric Power Transmission, Perrine's Electrical Conductors, and the two volumes on high tension power transmission recently issued by the same publisher. The last-named comprise the valuable papers presented in recent years before the American Institute of Electrical Engineers and the International Electrical Congress of 1904. Adam's book gives a good summary of the subject in small compass and in a very easy style. The book is well illustrated and it contains many useful data on general practice. An ample index increases its value as a reference work. To the general engineer it will probably prove as useful as the more elaborate and expensive works.

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WIECHMANN'S ELECTROCHEMISTRY.

Electrochemistry is rapidly coming to occupy a place as one of the most important practical arts as well as that of a scientific subject of the first rank. The possibility of securing cheap energy at water power sites has been a considerable factor in its development, for the energy item is the predominating expense in many of the processes. On the other hand the electrochemical industries have tended to force the development of the water powers by affording steady loads upon the power stations. Such loads are profitable, even with low prices for energy, as the stations operate continuously at maximum efficiency. In this connection it is only necessary to point to the great electrochemical center at Niagara Falls where a new and important industry has been created by cheap energy. Aluminum, carborundum, graphite, sodium, chlorine and many other substances are produced directly or indirectly by the electric current. In the production of pure copper, silver and other metals the current also plays an important part. So influential has the new industry become that a flourishing society is supported. This association, known as the American Electrochemical Society, with a membership of several hundred, recently held its ninth general meeting at Ithaca, N. Y. There is also a growing periodical and permanent literature devoted to electrochemistry, which is always a good indication of the real interest in any subject.

The latest contribution to the available text on electrochemistry is a small book published under the modest title, "Notes on Electrochemistry." In a limited compass is here given an excellent general summary of the present state of the science of the subject. The book is a practical one in the sense that elaborate theories are not treated. On the other hand it does not contain descriptions of the actual apparatus used in producing the different chemical substances, but merely gives the principles underlying each process.

The introductory chapters are devoted to a brief explanation of electrical properties and the elementary laws of electric circuits. A clear statement of the facts of electrochemistry is given and the subject itself is defined as "a study of the mutual relation and transmutation of electrical and chemical energy. It deals with electrical phenomena which are caused by chemical reactions, and chemical changes which result from the application of electrical energy." Then follow the main divisions of the work, electrolytic dissociation, electro-analysis, and electrotechnology. The first of these deals with the Ion Theory, which is the working basis of all electrochemical work. The second topic covers

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the application of this theory to chemical analysis. Under the heading "electrotechnology" the author discusses the important practical applications of electrochemistry. He classifies these as direct and indirect action processes and as electro-organic and electro-organic processes. These processes are simply and briefly described and this section will prove of great interest to the general reader.

The book as a whole is one which will repay careful reading by an engineer or scientific student, and demands only an elementary knowledge of chemistry. For those who desire to go further an ample bibliography is prefixed to each chapter. A novel feature is a name index by means of which the work of particular individuals may be readily found. There are 128 names in the list which includes practically all well known workers in this field of science and industry. An ample subject index is also provided.

ALEXANDER'S ELECTRICAL ENGINEERING

Elementary books on electrical engineering are of two general types; one intended to prepare the way for advanced study of the subject, the other designed to give a general view of the field with only enough of detailed explanation to render the treatment intelligible. Each class of book has its place, the former being of use to students who are laying a foundation for their technical education, while the latter will suit the purposes of practical engineers who wish to be familiar with current electrical practice. Assuming that its particular field has not already been covered and that it is well written and accurate, a new book in either class is a welcome addition to electrical literature.

In a 200-page book which would be placed in the second class mentioned above, Mr. Alexander has given a digest of a course of evening lectures delivered to classes of young artisans. The lectures were evidently intended to give the young men a systematic review of the objects seen about them in their daily work. The text is merely suggestive as, within the limits of a small volume, extensive descriptions would be out of the question. The text reads like a set of lecture notes which are to be elaborated by the speaker, hence the style is crude and the sentences are loose and disconnected. The material, however, is good and to electrical workmen who have had few opportunities for study it will be useful. The range of the treatment includes nearly every topic from the elementary theory of electric circuits to the generation and distribution of electric power. The latter covers boiler and engine practice, which can hardly be called electrical engineering. On the other hand, the telephone is not mentioned in the book, although the telephone industry is one of the most important in the entire field.

The first third of the volume is occupied with the elementary physical laws underlying electrical practice. The laws are illustrated by means of diagrams and with problems involving practically no mathematics. Following this section are a few chapters devoted to direct and alternating current generators and motors and to transformers. These chapters are the merest outlines of the important subjects named and are entirely inadequate, as is also the one treating of primary and secondary batteries. Electric lighting is given more attention and the lamps, as well as the circuits for conducting the currents, are described in some detail. Finally, the power station with oil, gas and reciprocating and turbine steam engines, boilers and auxiliaries, as well as hydraulic turbines, are discussed in 111½ small pages, which statement indicates the extent to which condensation has been carried in parts of the book.

HERRICK'S ELECTRIC RAILWAY HANDBOOK.

Mr. Herrick is a practical electric railway man who has devoted a great deal of attention to improvements in the operation of electric railways. He has had excellent opportunities for accumulating information regarding all kinds of equipment, and this has been arranged for reference in convenient form. The second edition of this handbook, issued five years after the first, is greatly improved in many ways. The troublesome flap has been omitted from the cover, and no advertisements mar the appearance of the book, as formerly. The volume is much smaller than the pocket-books of Foster and Dawson, but it is considerably larger than the first edition and it is devoted exclusively to electric railway and closely allied topics. The material is logically arranged in the following nine sections: General tables, testing, track, power station, line, car house, repair shop, equipment and operation.

The general tables include the usual selection, such as weights and measures, areas of circles, properties of steam and air and the electrical and mechanical properties of materials. The tables are followed by an excellent section on testing, a subject in which the author is a recognized authority. The tests described are all practical ones and clear working directions are given and illustrated by means of diagrams. The scope of the section includes all kinds of line, track, car and power station tests.

Track construction is discussed in some detail and several sets of specifications are given in full. The mechanical and electrical properties of rails are tabulated and cross sections of acceptable rails are shown, both alone and when forming part of the complete track. In connection with the rails the important subject of joints is considered. Diagrams and tables show the details of laying out simple and special curves and other special work and the section closes with several tables of cost data.

More than one-fourth of the book is included in the section on the power station. A large part of this is devoted to buildings, engines, boilers and accessories, but in addition numerous diagrams and tables are given showing the dimensions of electric generators, the arrangement and operation of storage batteries, connection and details of switchboards and kindred matters. Line work receives attention in the fifth section, and data are given for determining the proper sizes of overhead conductors to be employed. The author lays special stress on the mechanical construction of pole line and overhead work, and numerous practical schemes are shown for doing cheaply and conveniently the minor parts of such construction. The troublesome matter of electrolysis is not overlooked, a study of soil resistance, pressure drop in rails and bonding being included.

The last part of the book, comprising several sections, is devoted to rolling stock and its maintenance. Modern car construction, including bodies and trucks, is discussed briefly and a number of drawings of motors, controllers and detail apparatus are given, with dimensions. A very small space is made to suffice for the alternating current motor, which is unfortunate, as the systems employing this motor may now be considered as entirely satisfactory.

The synopsis given above will serve to indicate clearly the classes of readers to whom the book will be useful. It is well printed and bound and is quite compact, considering the amount of information contained. A satisfactory index is included.

THE MANUAL OF STATISTICS.—Stock Exchange Handbook. 1906. New York: The Manual of Statistics Co. Cloth; 5½ × 8 ins.; pp. 1,056; tables and folding maps. $5.

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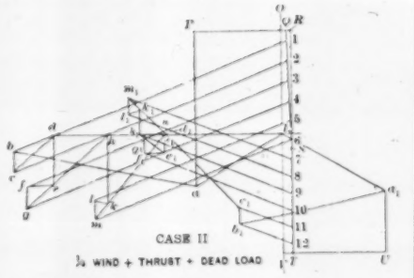

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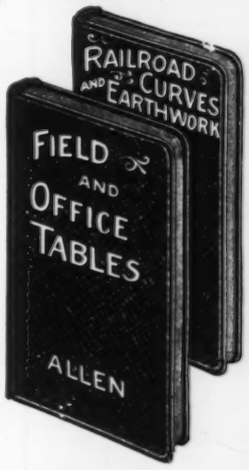

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Producer-Gas and Gas-Producers.

Reviewed by Alfred E. Forstall.*

A TREATISE ON PRODUCER-GAS AND GAS-PRODUCERS.—By Samuel S. Wyer, M. E., Jun. M. Am. Soc. M. E., M. Am. Inst. M. E., Author "Catechism on Producer-Gas." New York and London: The Engineering & Mining Journal. Cloth; 6 x 9½ ins.; pp. 296; 113 figures in the text. $4.

Although producer-gas has played an important part in the iron and steel industry for more than thirty years, it is only of recent years that attention has been given to it by those concerned in other industries. That this attention is rapidly becoming more general and more keen is shown by the many articles in technical periodicals, papers presented to engineering societies and books dealing with producer-gas which have appeared during the last two years.

The book now reviewed is one of several that have been considered in these columns during that period. While it covers much of the same ground as its predecessors it differs from them in devoting more space to principles and less to descriptions of different makes of producers, a method of treatment which is to be commended. The first two chapters deal with the physical and chemical laws, which it is necessary to know before it is possible to have a clear understanding of the problems involved in the handling of gas-producers and the utilization of the gas produced by them. Then comes a consideration of thermal and physical calculations, including those needed to obtain the calorific value, weight and volume of, and heat carried away by, the products of combustion, and the flame temperature of the mixture of gases of which producer-gas consists.

The special subject of the book is next taken up and carried through the present position of producer-gas in the industrial world, the classification of gas producers, according to various methods based upon distinctive features of their operation and design, the theory of the manufacture of producer-gas, including the use of steam in its production and the effect of carbon dioxide upon it, and the efficiency and heat balance of, and the requirements to be met by, gas producers. There then follows a brief history of the development of gas producers and descriptions of the various forms of pressure and suction producers that are in use in America, after which by-product gas-producers of the Mond type, by-product coke ovens and gas-producers specially designed for the use of wood as fuel are described.

After this descriptive portion the treatment of producer-gas for the removal of tar is taken up, as are also the various purposes to which this gas can be applied, both as a fuel and in the direct production of power by means of gas engines, the operation and testing of producers and the future possibilities in the way of the replacement of the present forms of locomotive, marine and portable steam boiler and engine equipments with producer-gas plants and gas engines. There is then given a chapter on carbon monoxide poisoning, and the treatment of persons affected by it, which is followed by ten pages of reference data, including tables giving the weights at various temperatures of both dry air and air saturated with moisture; data as to the loss by radiation under various conditions and as to the discharge of gas through pipes of various sizes and various lengths; and also tables of the solubility of gases in water, the melting points of various substances and the variation in the specific heat of carbon dioxide with increase in temperature. The last chapter gives the bibliography of gas-producers arranged chronologically by years from 1841 to 1905 inclusive.

In the chapter devoted to thermal and physical calculations the methods employed are illustrated by exmaples which are worked out. In connection with the calculations of flame temperature and the amount of heat carried away by the products of combustion more emphasis should be laid upon the increase which takes place in the specific heat of gases as the temperature increases. The fact that such an increase takes place is noted in connection with the definition of specific heat, and is also shown by the table giving the specific heats of carbon dioxide at various temperatures, but in using the specific heats the values employed are those for ordinary temperatures, although the temperatures that are being dealt with are much higher than ordinary, so that the results obtained by the calculations as made are far from being correct. This is a very common fault, but in view of the attention that has been given to the increase of specific heats with temperature is one that should no longer be made.

Another fault noted is in the writing of the equations for the reactions occurring during combustion as if the molecule of oxygen contained only one, instead of two, atoms. Unless equations are correctly written it is impossible to derive from them the proportionate volumes in which different gases combine with each other. For instance, the equation for the combustion of marsh gas is given as $CH_4 + 4O = 2H_2O + CO_2$. This means that four volumes of oxygen are required to consume one volume of marsh gas, and does not agree with the statement made later in Table No. 3 that two volumes of oxygen are required to burn one volume of marsh gas, while if the equation had been written correctly, $CH_4 + 2O_2 = 2H_2O + CO_2$, the equation and the statement in the table would have agreed.

The descriptive portion of the book is fully illustrated and enables a very good idea to be obtained of the different forms of gas-producers described and of the different appliances used for removing from the gas the dust and tar which it contains when it leaves the producer.

In connection with the subject of tar removal, the author is rather too optimistic in regard to the possibility of entirely preventing the formation of tar by so designing the producer as to cause the gases distilled from the fuel in the early stages of the operation to pass through a greater or less depth of incandescent fuel, and too pessimistic as to the possibilities of completely removing the tar from the gas after it leaves the producers. It is very difficult to entirely decompose tar by passing the gas containing it through incandescent fuel, while the experience of illuminating gas manufacturers shows that it is neither difficult nor expensive to entirely free gas from tar, and it would be safer to provide for its removal instead of trusting to its destruction in the generator.

In spite of the faults noted, this book will be found valuable by the constantly increasing number of persons with only a slight knowledge of physics, chemistry and the metallurgy of fuels who wish to take up the study of producer-gas, since it treats the subject in such a way as to supply to a great extent the knowledge of fundamental principles which is absolutely necessary before one can solve the problems involved in the manufacture and use of this gas.

*Consulting Engineer. Late Secretary American Gas Light Association, 58 William St., New York City.

The Steam Engine Indicator.

Reviewed by Lionel S. Marks.*

THE INDICATOR HANDBOOK.—A Practical Manual for Engineers. By Charles N. Pickworth, Whitworth Scholar, Editor of 'The Mechanical World," Author of "The Indicator Diagram: Its Analysis and Calculation," "The Slide Rule," "Logarithms for Beginners," etc. Third Edition. In two parts. Manchester and London, Eng.: Emmott & Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4¾ x 7½ ins. 3s., net, per volume; American price, $1.50 per volume.

Part I. The Indicator: Its Construction and Application. Pp. 130; 81 figures in the text.

Part II. The Indicator Diagram: Its Analysis and Calculation. Pp. 132; 148 figures in the text.

The literature devoted to the steam engine indicator has grown largely in volume in recent years but has shown very little tendency to thoroughness of treatment or to originality of point of view. The instruction books issued by some of the makers of indicators are as complete in their general treatment of the subject (though, naturally, they are devoted to indicators of one make only) as the majority of the books published for sale and within their scope are entirely satisfactory. The two attractive little volumes

*Assistant Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.

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by Pickworth are to be welcomed because they attempt to go further than most of the books, because there is an attempt to analyze and discuss some of the details of the action of the indicator, and because the author has made himself acquainted with the results of experimental investigation of the indicator and has endeavored to profit thereby.

Part I. deals with the indicator, its attachment and the reducing gears. Part II. is devoted to the indicator diagram. The descriptive part of the book is fairly complete so far as the more prominent types of indicator are concerned, but one misses the flat-spring Batchelder indicator and the rotary Wayne indicator. The omission of the Wayne indicator (which, however, is incidentally referred to in one or two places) is surprising in view of the fact that it is the instrument selected for their investigations by the Gas Engine Research Committee of the Institution of Mechanical Engineers, who state that "in careful hands it is apparently the most accurate indicator at the present time." While this instrument is omitted, a paragraph is devoted to so useless and unreliable an instrument as Ripper's Mean-pressure Indicator.

It is the chapters devoted to the errors of the indicator and to the indicator reducing gear that justify the existence of this book; all the other matters dealt with are equally well treated in easily accessible books in the English language. The errors of the indicator discussed include those due to piston friction, to imperfection and incorrect rating of springs, to imperfect pencil motion, to pencil friction, to inertia of the moving parts, to drum troubles and to springing of the instrument. The statement that the error in new springs by the best makers may amount to as much as 3% surely strains the definition of best makers. The inertia effect is described in a general way and the actual equivalent mass of the moving parts is given for one make of indicator for a definite spring; it would have added to the value of this part of the book had the author determined the equivalent mass for each of the half dozen instruments that he discusses in most detail. In the discussion of pencil friction it is stated that the effect of such friction is, among other things, to cause the steam line to be drawn above and the back pressure (i. e. exhaust) line below their true positions thus increasing the area of the diagram. The reverse surely is the case; the effect of friction will be to decrease the area so far as it is affected by the steam and the exhaust but to increase it so far as it is affected by the expansion and compression.

The most interesting part of the book is in chapters six and seven of the first volume, which deal with indicator reducing gears and their errors. An unusually large number of gears is described and their errors are either shown graphically or are stated verbally. The method adopted for showing graphically the errors of the reducing motion is to place side by side two scales, one, of equal parts, showing the piston travel, and the other showing the corresponding drum movement. If the total movements of both piston and drum are represented by the same total lengths all the subdivisions will come opposite one another, if the reducing motion is correct. Unfortunately, the author has chosen total lengths which are slightly different in most of the gears analyzed so that the results of his work are by no means as clear as they might be. Attention is particularly to be drawn to a simple pendulum motion in which a pin at the free end of the pendulum slides in a slot attached to the crosshead exactly at right angles to the center line of the engine, while the motion of the indicator is taken from another pin. This very simple, easily constructed gear gives practically perfect motion to the indicator; it is almost unknown in this country. Another interesting result in the same chapter is the considerable error of the very common reducing motion consisting of a pendulum whose free end is driven by a link from the crosshead while the indicator cord is attached to a brumbo pulley; the results are much better when a pin is substituted for the brumbo pulley.

Part II. deals in a very detailed way with the varieties of form of the so-called lines (admission, steam, expansion, exhaust and compression) of which the indicator card is made up and with the causes of departure from the normal forms. The diagram as a whole is next considered and the effects on it of type of valve gear, imperfect valve setting, leakage, faulty engine design, load and other factors are discussed. Then follow chapters on diagrams from compound engines (including combining diagrams), diagrams from gas and oil engines, from air compressors, pumps and other appliances. A final chapter is devoted to diagram calculations.

The second part is painstaking and accurate but does not add to the good impression which remains after reading the first part. On the whole, the reviewer knows no better book on the indicator. It is to be hoped that the two parts will be combined in a single volume in future editions.

THE BATTLES OF LABOR.—Being the William Levi Bull Lectures for the Year 1906. By Carroll D. Wright, Ph. D., LL. D., President of Clark College; Author of "Industrial Evolution of the United States," Outline of Practical Sociology," etc. Philadelphia, Pa.: George W. Jacobs & Co. Cloth; 4¾ × 7½ ins.; pp. 220. $1, net.

All four of the lectures making up this little volume are interesting and well worth reading, but the last is of the greatest value, since in it the author gives more expressions of personal opinion based on his long and intimate acquaintance with labor problems than are to be found in the other three addresses. The volume opens with "The Background," in which the reader is shown some of the earliest struggles of labor of which we have record. The first "great battle which labor fought," the author says, "was the strike of Moses and the Jews, known in sacred history as the Exodus." Many other interesting events recorded in ancient history are cited as incidents in the struggles of labor for advancement. The second lecture deals with medieval and modern industry. The third reviews "Great Modern Battles," beginning with the Baltimore & Ohio and the Pennsylvania strikes of 1877 and continuing on to the anthracite strikes of 1900 and 1902. The closing lecture is entitled, "How Modern Battles of Labor Are Treated," and contains many sensible and judicial remarks on the modern labor problem.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.—Proceedings for 1906. Chicago: E. E. R. Tratman, Secretary, 1636 Monadnock Block. Paper; 6 × 9 ins.; pp. 200; illustrated. 50 cts.

The subject-matter relates largely to municipal engineering (streets, sewerage and water supply). A review of the development of the septic tank is contributed by Mr. J. W. Alvord. There are also papers on land drainage and irrigation, mining engineering, concrete work and surveying; among the last are notable papers on a government triangulation survey in Montana and the government surveys of the Des Plaines and Illinois rivers with regard to the proposed waterway connecting Lake Michigan with the Mississippi River.

KIRCHOFFER'S DIAGRAM FOR ESTIMATES OF PIPE SEWERS.—W. G. Kirchoffer. Baraboo, Wis.: The Author. Single sheet; 6 × 9 ins. 25 cts.

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An English Treatise on Tunnel Shields.

TUNNEL SHIELDS AND THE USE OF COMPRESSED AIR IN SUBAQUEOUS WORKS.—By William Charles Copperthwaite, M. Inst. C. E., Bridge Engineer of the London County Council. New York: D. Van Nostrand Co. Cloth; 7½ x 11 ins.; pp. 389; 258 illustrations, mostly in the text. $9 net.

In extent and cost, the subaqueous tunneling work now in progress in this country probably exceeds all other tunneling work combined. In venturing this statement exclusion is, of course, made of the open-cut underground railway tunnels or subways under city streets that are now being built in several of our large cities, notably New York, Boston, Philadelphia and Chicago. In Europe the numerous great Alpine tunnels under way probably throw the balance to the other side, but the aggregate of subaqueous work is very large. Practically all of this tunneling through water-bearing strata is being done with shields. As an instance there are now in progress a round dozen of shield driven tunnels under the waters of the Hudson and East Rivers at New York City. It is plain, therefore, how a book on tunnel shields, even when of the volume and cost of the one before us, should have come to be written, and it is likewise plain, when we recall the almost equally great works of shield tunneling in the past, how the material could have been obtained for such a monumental volume.

The literature in English on shield tunneling is voluminous. American and British engineering journals and the papers read before the various engineering societies in both countries have, first and last, described nearly every British or American built shield tunnel, and for continental practice the German and French periodical press, and particularly Mr. Legouez's excellent work on "L'Emploi du Bouclier dans la Construction des Souterrains" give all essential information. Mr. Copperthwaite's task has been to compile and condense this scattered information into one place. He has done his work excellently in most particulars; to our recollection few, if any, important features of shield tunnel work have been omitted from mention except the very recent developments in America and in France. Compared with Mr. Legouez's treatise the book before us is quite as complete in its descriptions of tunnel works, but in the analysis of shield construction, in the comparison of advantages and disadvantages of shield work, and in critical discussion generally, the French treatise seems to us to stand superior. Of English books on tunneling, only Prelini's "Tunneling" and Stauffer's "Modern Tunnel Practice," aside from the book before us, give any adequate information on the shield method, and these being general treatises on tunneling devote of necessity much less space to shields than the more recent special work.

Mr. Copperthwaite divides his book into eleven chapters. Of these the last chapter, on "Cost of the Shield," and the first three chapters on "Early History, 1818-1880," "Use of Compressed Air in Engineering Works" and "Cast-Iron Lining for Tunnels," respectively, are general in character; the remaining seven chapters are collections of descriptions of specific shield tunnel works classified under three heads: Shields in London Clay, Shields in Water Bearing Strata and Shields in Masonry Tunnels.

Historically considered, the author finds the first mention of a shield for tunnels under water in the English patent No. 4,204, issued to Marc Isambard Brunel in 1818. This patent describes "a casing or cell to be forced forward before the timbering generally employed to secure the work." Brunel tested his shield in the Thames tunnel of 1825-28; but as he had supposed that the soil was clay and practically impervious to water, the presence of loose and water-bearing material caused failure. His original patent proposed the pushing forward of separate cells by means of hydraulic jacks, the face of the excavation being protected by ordinary poling boards. These cells combined occupied the circular area of the tunnel proper, the cells moving on each other on rollers. Brunel improved upon his design, and with the new shield the Thames tunnel was completed in 1843. The new shield consisted generally of a broad diaphragm which was pushed forward by hydraulic jacks abutting against the finished masonry; and the diaphragm itself formed a point of support for a multitude of small screw-jacks supporting poling boards and holding these in place as the face excavation advanced.

But the shield alone would have been of comparatively little use had it not been for Sir Thomas Cochrane, who in 1830 described the application of compressed air to shaft-sinking and tunneling in water-bearing materials. It is to the combination of these two devices, the shield and the use of compressed air, that the great subaqueous tunnels of the last twenty years have been made possible.

Succeeding Brunel various patents have been taken out for shields. The author describes P. W. Barlow's shield of 1864 and 1868; the shield of R. Morton, of Stockton-on-Tees, of 1866; and the Beach shield of 1864. Barlow himself never put his ideas into practice; but Mr. James Henry Greathead designed a shield for the Tower Subway, under the Thames, of similar character to the Barlow shield of 1868. The main features of the Barlow patents were: The cast-iron lining to the tunnnel; the grouting outside the shell; the cylindrical overlapping of the shield; the use of screws or hydraulic presses, and a transverse diaphragm or open frame. The Tower Subway, of 1869, says the author, was the first tunnel built of cast-iron with grout filling; and the first tunnel of any kind built with a shield movable in one piece. But at the same time that the Tower Subway was projected by Barlow in England and carried out by Greathead, Beach, in the United States, actually drove an 8-ft. subway through loose, sandy soil under Broadway, in New York City. The shield devised by Beach was formed of a heavy timber ring with a cast-iron cutting-edge, and was provided in the rear with a wrought-iron forged ring which distributed the thrust of the hydraulic rams reaching against the finished masonry. To the rear end of the timber ring was attached a flexible overlapping shell of steel protecting the opening made at each advance of the shield. The hydraulic rams here employed were the first used anywhere in a shield. The face of the excavation was supported by a series of horizontal iron shelves. Mr. Greathead is credited with designing and constructing, in 1874, the first shield built with a water-seal, and the first designed to work by compressed air. This shield was designed for a proposed tunnel under the Thames at Woolwich, but was never used as the tunnel was not built. Mr. Greathead also designed mechanical plate-erectors for this tunnel, the first on record.

In closing his introductory chapter the author states that three men—Barlow and Greathead, in England, and Beach, in the United States—were undoubtedly working independently on the shield problem in the late sixties, and very likely at an earlier date. He credits Barlow with being the first to patent, in 1864, a shield capable of motion in one piece and surrounded by a shell of thin iron within which were built the successive rings of a cast-iron tunnel. But Greathead and Beach, in 1869, were the first to actually construct and use such shields.

In the second chapter the author takes up the subject of compressed air as used in engineering work and describes and illustrates the typical tunnel air-lock; he follows this with detailed descriptions of some of the earlier bridge foundations built by the aid of compressed air. This chapter also contains a very full discussion of the effects of compressed air on the health of compressed air workers and the precautions necessary to avoid, and the remedies for, caisson disease.

The chapter on cast-iron lining for tunnels opens with a general discussion of the development of cast-iron lining and of its advantages and general design. This general matter is followed by specific descriptions of the linings actually used in nine subaqueous tunnels. There is also a brief and interesting description of the casting of tunnel lining segments, in which is described the molding machine for tunnel segments of the British Hydraulic Co. We may mention here also the final chapter on costs. The author gives first the costs of several representative shields and states that including all the mechanism of the shield proper a modern tunnel shield will range in cost from £25 to £55, or approximately $125 to $275, per ton. Following these figures are tabular statements of the costs of some typical shield tunnels.

The seven chapters given up to descriptions of individual tunnels built by the shield method must be passed over with a few general remarks. Hardly a European or American tunnel of magnitude is unmentioned, and of most of them the description is full and detailed. The author, however, has not been particularly conscientious in following up the most recent work in America. His description of the Hudson River tunnel

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for example, stops with the suspension of work in 1901; the work of the last three years, by which the original project has been carried to completion, is not described. No mention is made of the East River tunnel of the Rapid Transit Railway, or of the Pennsylvania Railroad tunnels now being built under the North and East Rivers. There is excuse for this omission, of course, in the uncompleted condition of these works, but their novelty and difficulties will demand a place for them in a new edition.

The publisher's work on the book is good, and there is an adequate index. The volume is in all respects worthy of prominent position in the tunnel engineer's library.

Metallurgical Calculations.

Reviewed by Bradley Stoughton.*

METALLURGICAL CALCULATIONS.—By Joseph W. Richards, A. C., Ph. D., Professor of Metallurgy in Lehigh University, Author of "Aluminum, Its Metallurgy, etc." Part I. Introduction, Chemical and Thermal Principles, Problems in Combustion. New York: McGraw Publishing Co. Cloth; 6 x 9¼ ins.; pp. 208. $2, net.

The larger part of Prof. Richards' book is a reprint of a serial running in "Electrochemical and Metallurgical Industry" from March, 1905, to March, 1906. To this has been added in an appendix the statement of a number of problems for practice, which it is hoped will still further increase the usefulness of the work. It is intended that the serial which is now appearing during 1906 shall appear as Part II., and that which shall appear during 1907 as Part III., completing the work.

The value of this book will be recognized at once by all metallurgists and chemists engaged in metallurgical work. It forms another and a very important step in the application of science to metallurgy. It will also be of the greatest advantage to students, serving to rivet their attention on the details of the various metallurgical processes, to stimulate thought and to assist their comprehension of many of the underlying principles. The treatment of the subject is logical and clear, with the exception only of the disadvantages mentioned in the last paragraph of this review. The examples chosen for illustration are representative and capable of being extended by any intelligent engineer to cover a wide variety of calculations.

The book starts with a discussion of the chemical equation, illustrated by calculations of the volume of air necessary to burn certain fuels, and the volume and composition of the products of combustion under different conditions. Chapter II. deals with the applications of thermochemistry. This is continued in Chapter III., "On the Use of Thermochemical Data," which is illustrated by calculations of calorific power, calorific intensity, relative efficiency and cost of various fuels under different conditions. The text then passes naturally to Chapter IV., "On the Thermochemistry and Thermophysics of High Temperatures," illustrated by calculations of the efficiency of different furnaces. The thermophysics of alloys, which is almost virgin ground, is included in this chapter. Chapter V. then takes up the thermophysics of chemical compounds, which is illustrated by examples in calculation and includes the subject of the decomposition of ores by chemical reagents and by electricity, and explains the relation, both commercially and otherwise, between the two methods. The subject now changes and Chapter VI. discusses artificial furnace gases. The problems serve as a review for some of the previous calculations, and as a study of the comparison of the different types of producers, etc. Chapter VII. also serves partly as a review and includes the subject of chimney draft and forced draft. Chapter VIII. is a short statement of the principles of the conduction and radiation of heat.

The two greatest defects in the book are: (1) In working out the solutions of the problems cited, space has been economized as much as possible; consequently there is very little explanation given with the figures and one has sometimes to search a long time to understand just what they represent. While this is undoubtedly good practice, it is very discouraging to students, or to a very busy man. (2) The book is lacking in references to other literature of the subject. If some references were given where further data (for example, thermochemical and thermophysical constants, such as heats of combination, specific heats, etc.) could be found, it would be of great assistance, because a book of this size cannot include all of these, though the ones necessary for the calculations included, and for many others like them, are, of course, given.

*Adjunct Professor, Department of Metallurgy, Columbia University, New York City.

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This is by far the best technical dictionary, for finding the equivalents of words in one language and those of a number of others, that we remember having seen. The equivalents in the six languages are placed in two columns on each page, with illustrations where possible of the apparatus or devices listed. The drawings, though small, are very satisfactory for their purpose. Where occasion demands, formulas are given in place of diagrams. The subjects covered are divided broadly into machine elements and tools, engineering drawings, and miscellaneous or general. Screws and bolts are first taken up, and then are followed by keys, rivets, axles, etc. It will be seen that the arrangement is not alphabetical, and it is obvious that such an arrangement would be well-nigh impossible and, in any event, would be confined to one language. A very full index (about 150 pages) will enable any one to refer quickly to any word which he wishes to find. The typography and paper are very satisfactory, the book opens well, as such a volume should, and altogether the publishers, both foreign and American, are to be congratulated upon their production. It may be added that the book is originally published in Germany.

ENGINEERING TABLES AND DATA.—For the Use of Students in Laboratories; also for Class and Home Work Exercises. By W. W. F. Pullen, M. I. Mech. E., Assoc. M. Inst. C. E., Professor of Mechanical Engineering, South Western Polytechnic, London. Second Edition. Manchester, Eng.: The Scientific Publishing Co. Cloth; 5⅛ x 8¼ ins.; pp. 87; 21 figures in the text. 2s. 6d., net; American price, $1.

This collection of tables and data, while not intended to displace the engineers pocketbook, should be found very convenient by the student in the mechanical laboratory and others for the solution of problems, as there are combined in this one volume tables of the natural functions of angles and logarithms, steam, entropy, water density, and conversion tables together with all the commonly used mensuration formulae, analytical equations, algebraical and trigonometrical series, standard integrals, differential coefficients and equations, hyperbolic functions and trigonometrical relations.

THE SEVEN FOLLIES OF SCIENCE.—A Popular Account of the Most Famous Scientific Impossibilities and the Attempts Which Have Been Made to Solve Them. To Which Is Added a Small Budget of Interesting Paradoxes, Illusions and Marvels. By John Phin, Author of "How to Use the Microscope," "The Workshop Companion," "Century of Inventions," etc. New York: D. Van Nostrand Co. Cloth; 5¼ x 7¾ ins.; pp. 178; 34 figures in the text. $1.25, net.

The author takes for his seven follies of science, the squaring of the circle, the trisection of an angle, the duplication of the cube, perpetual motion, the transmutation of metals, the fixation of mercury and the elixir of life. In a chapter devoted to each of these subjects he explains the origin of the problem, outlines historically the attempts that have been made to solve it, and finally explains why its solution is impossible. Following these main chapters are two others presenting and explaining certain paradoxes, illusions and marvels, and some curious arithmetical problems. The book makes interesting reading for an idle hour, and one could wish that it might be read with conviction by those who waste time on the follies of which it speaks. Unfortunately, however, the class of mind that occupies itself with perpetual motion or the quadrature of the circle is not the class of mind to which the reasoning of the author will appeal, and we may expect in the future as in the past to hear at frequent intervals of some one's "solution" of one or another of the seven follies of science.

TELEPHONES AND TELEGRAPHS, 1902.—Special Reports, Bureau of the Census. S. N. D. North, Director. Washington, D. C.: Pub. Doc. Paper; 9 x 11½ ins.; pp. 172; 37 plates, five diagrams and numerous tables.

The statistics of this report cover the calendar year ending December 31, 1902, and concerns the physical equipment service and financial operations of the commercial and mutual telephone and telegraph systems of the country, and the physical equipment of independent rural telephone lines. Data is also given relative to the systems controlled in whole or in part by the railway companies, and the ocean cable systems that were in operation all or part of the year. This is the last of a series of reports on the generation and utilization of electric current, and closes the first complete census of the generation and utilization of electric current for the transmission of power, messages and conversation.

TABLES OF FIVE PLACE SQUARES AND LOGARITHMS.—Of Feet, Inches and 32ds of Inches, from Zero to 100 Feet. Logarithmic Secants for Hip, Valley and Rafter, from Zero to 18-Inch Rise to 1-Foot Base, Advancing by 32ds. Logarithmic Functions, Natural Sines and Co-sines for Every Minute of the Quadrant. By G. D. Inskip. New York: The Myron C. Clark Publishing Co. Flexible leather; 5¾ x 7¾ ins.; pp. 277; diagrams. $3, net.

The contents of this handy volume are well indicated by the title page, as given above. Earlier tables by the same author, covering much less ground, and superseded by this one, were noticed in this supplement for June 16, 1904, and April 13, 1905. The flexible leather binding is the most satisfactory that we remember having seen on a pocket book.

A French Treatise on Water Supply.

Reviewed by George C. Whipple,* Assoc. M. Am. Soc. C. E.

DISTRIBUTIONS d'EAU.—Assainissement des Villes. By A. Debauve, General Inspector and Professor, l'Ecole des Ponts et Chaussées, and Ed. Imbeaux, Director of Municipal Works, Nancy. Third edition, revised and greatly enlarged. In three volumes. Paris, France: H. Dunod & E. Pinat. Paper; 6½ × 9¾ ins.; pp. 732 + 579 + 608; many text figures and tables; 72 plates in separate volume, 9¾ × 12½ ins. 75 francs; American price, $22.50.

It is interesting to observe how enthusiasm in scientific research along any particular line shifts from one country to another. Just as there have been schools of art—the Italian school, the Flemish school, the French school—so there have been schools of science, stimulated generally by the work of one man or of a group of men. Bacteriology originated in France with the illustrious Pasteur, then the interest shifted to Germany on account of the brilliant researches of Koch; while England, America and other countries have from time to time become prominent. So also in water purification. England took the lead, Germany followed, while America in recent years has surpassed them both by her profound studies into the science of filtration and by her practical application of the principles involved to waters of varied character. France, meanwhile, in spite of the fame of her engineers, has been lying dormant. There are signs of an awakening, however, and it is not at all unlikely that in the near future we may have to go to France to study the latest developments in water-works engineering, just as to-day we go to England to study sewage disposal. It is perhaps not too much to say that the publication of the new and magnificent work on water supply by Debauve and Imbeaux marks the beginning of a French renaissance.

The book is a comprehensive one, covering all phases of water-works construction and operation. It is really the third edition of the work, but so much new material has been added that it is practically a new treatise. The plates add materially to the value of the work, but in studying them one cannot help wishing that they had been reduced somewhat in size where necessary and scattered through the three volumes of text for more convenient use. The absence of an index is most conspicuous, and most unfortunate in a book of this size, although the well-arranged table of contents and the bold head-lines of the text partially supply the omission.

The three volumes relate to different divisions of the subject: the first to theoretical hydraulics, the quality of water and methods of purification; the second, to sources of water and methods of development; the third, to storage and distribution. Each volume is divided into several parts. Part one, of the first volume, treats of theoretical hydraulics, methods of measuring flow by weirs, orifices, etc., and the flow of water in pipes, conduits and channels. There is a chapter on water meters, but this subject is treated somewhat superficially, and has not received the attention which it demands. Comparatively little is said about water waste. Clearly the French are behind the English in the restriction of the use of water. As filtration plants multiply in France this matter will be doubtless forced upon their attention, as it has been elsewhere. The accompanying figures, compiled from tables given in the second volume, illustrate the relatively lavish use of water in France as compared with England and Germany, but its economical use as compared with America:

*Consulting Engineer, 220 Broadway, New York City.

Part two of the first volume treats of the quality of water. This is taken up in a broader and more practical manner than in most foreign books on the subject. The numerous quotations from American writings are conspicuous; in fact so far as the physical properties of water are concerned very little is quoted from other sources. The absorption of light by water, which has an important bearing on certain problems involved in water storage, is beautifully illustrated by the experiments made by Regnard at Monaco in 1890. The results were obtained by taking advantage of the principle that the electrical resistance of selenium varies according to its illumination. The methods of chemical and bacteriological analyses of water represent French practice, and have but little interest for American readers. The microscopic organisms in water are discussed at some length and quite fully illustrated. Here also recognition is given to American studies, but the greater part of the chapter reflects the work of the "Plankton" investigators on the continent, though much of the German work is omitted. In this connection it might be stated that there is a very general omission of references throughout the book. Quotations are properly acknowledged, but the reader is not always informed where he may find the original articles. The chapter on the effect of drinking water on the public health contains descriptions of certain epidemics of typhoid fever and cholera which have occurred in France and elsewhere. A table is given which illustrates a fact that is more and more attracting the attention of sanitarians, namely, that when a city changes its water supply from a source which is contaminated to one which is not there is a lowering of the general death rate by an amount very much greater than can be accounted for by the decrease in typhoid fever. Twelve cities are given to illustrate this for periods of five years before and after the change in water supply. They show that whereas the average death-rate from typhoid fever decreased 69 per 100,000 after the introduction of pure water, the general death-rate decreased 410 per 100,000, or about six times as much. Typhoid fever statistics are given for many French cities and it is shown how during the last 17 years the average typhoid death-rate has fallen from 52 to 21 per 100,000. The average typhoid death-rate for Paris is about the same as for New York, namely a little less than 20 per 100,000.

The third part of the first volume relates to filtration and sterilization of water. This subject is taken up systematically and, on the whole, satisfactorily. Some novel methods of treatment are suggested. For instance, a method of cooling water by allowing a part of it to evaporate through porous pipes is suggested, and the reviewer recently saw the device being installed at St. Maur, near Paris, for accomplishing this object. Methods of removing the turbidity of water and of softening it for industrial uses are described, but few new ideas are presented. Sand filtration is, of course, discussed at length and differences between English, German and American methods are set forth. There is also a fairly complete résumé of mechanical filtration, based on American practice, but supplemented by descriptions of certain English and French proprietary devices. The subject of sterilizing water by heat and by the use of chemicals is described at greater length than in most water-works treatises. The use of ozone for water purification at various places in Europe is described. The advantages of its use are set forth, as well as some limitations to its application. The important matter of cost, however, is passed over too lightly.

The second volume, which relates to methods of developing ground and surface waters, is largely descriptive. It should be especially interesting to American engineers, as many of the illustrations are of foreign works too little known in this country. The volume opens by referring to the quantity of water necessary to be provided for municipal purposes, and to rainfall as the ultimate source of supply. A few French statistics of rainfall are given. Methods of taking water from lakes and of storing water in reservoirs are discussed at length, but the greater portion of the volume is devoted to underground water supplies. This is perhaps natural in a French book, as ground water is so common a source of supply in France. On the whole this section relating to ground water is perhaps the most valuable part of the work to American engineers. French interest in the subject is also shown by the numerous quotations from the theoretical studies on the lateral flow of water in the soil, percolation, etc., made by Slichter, Hazen, King, Whipple and other Americans.

In the third volume there are chapters on gravity supplies, pumping machinery, motors and windmills, the latter subject being one seldom considered in American water-works treatises. There is a chapter on pipes and conduits, wherein is described the methods of manufacture and the use of cast iron pipes, as well as steel pipes and pipes of concrete-steel. Electrolysis is discussed briefly. Distribution reservoirs and stand-pipes are treated theoretically and numerous descriptions of French work are given. The care of distribution systems, prevention and removal of incrustations, prevention of freezing, etc., are also taken up. The last chapter in the book relates to French legislation on water supply matters.

The work is a valuable one for the American

TABLE SHOWING THE AVERAGE PER CAPITA WATER CONSUMPTION IN GALLONS PER DAY FOR CITIES OF DIFFERENT POPULATIONS IN FRANCE, GERMANY, ENGLAND AND AMERICA, 1902.

	Populations above 100,000		Populations between 50,000 and 100,000.		Populations between 25,000 and 50,000.	
	Number of Cities Averaged.	Per Capita Consumption. Gallons per day.	Number of Cities Averaged.	Per Capita Consumption. Gallons per day.	Number of Cities Averaged.	Per Capita Consumption. Gallons per day.
America	22	129				
France	16	52	12	78*	12	58
England	41	31				
Germany	28	80	10	30	5	18

*This high figure is due in part to the use of water for irrigation.

TRAUTWINE'S
CIVIL ENGINEERS' POCKET BOOK

18th Edition, 1906
$5.00
JOHN WILEY & SONS
Scientific Publishers
42 and 45 East Nineteenth Street
NEW YORK CITY

engineer as a book of reference on account of its many descriptions of foreign water-works plants, while it cannot help having an important influence on French practice on account of the great amount of American, English and German data which is included, and much of which is here for the first time translated into French. The authors deserve great praise for the painstaking manner in which they have collected, digested and arranged this enormous amount of information on water supply subjects.

Special emphasis should be placed upon the value of the supplementary volume of plates. From the old Roman aqueducts up to modern pumping and filter plants these plates show in great detail and with great clearness the development of the art of supplying water to municipalities. In no volume with which the reviewer is familiar have so many interesting details been brought together for convenient use. The plates are classified to correspond with the subdivisions of the text.

The Tachymeter.

Reviewed by Horace Andrews.*

LE TACHEOMETRE.—And Its Applications to Land-Surveying and to Railway Lines. By Joseph d'Angelo, Civil Engineer. Paris: Ch. Béranger. Paper; 6 x 9¼ ins.; pp. 203; 164 illustrations in the text. 10 francs; American price, $3.

A tachymeter has been defined as a theodolite provided with arrangements for measuring both horizontal and vertical angles and also with a distance measurer in the telescope, and, generally, with a compass.

A work of only 200 pages might be devoted to the theory, description and use of the tachymeter as thus defined. Mr. d'Angelo has, however, added to his work a concise and excellent description of instruments employed in photographic map work and has treated extensively of tachymeters that give horizontal and vertical distances automatically. Many of these seem more curious than useful.

The book is full of interesting suggestions for the designer of instruments or for one formulating specifications for tachymeters. Italian instruments are well described, illustrated and advertised, especially those of Salmoiraghi, of Milan. Ignace Porro, a colonel of the Italian army, is accredited with being the first to render the tachymeter method of practical importance. Porro's well-known device, which enables stadia measurements to start from the center of the instrument, through the insertion of an extra lens in the telescope, is very well and thoroughly described.

The second and third chapters of the book, comprising 38 pages, are devoted entirely to optics and a development and analysis of "Anallatisme," or Porro's device.

The instruments described by the author have the circles divided on the centesimal system, their vertical circles indicate zero with pointing to the zenith. They have inverting, "anallatic," telescopes, and the cross wires are lines cut on glass. All of these devices seem very practical and praiseworthy and would contribute to rapid and accurate work. The compass needle is frequently placed in a tube, thus giving the magnetic meridian only.

It is to be regretted that the author has not made a distinction between tachymetry of the first and second class. Many details of instruments described would be useful only in first-class work, where high precision is sought rather than great speed. Powerful microscopes with a finely divided limb are one of the departures from usual construction that might be a desirable improvement with instruments for all classes of tachymetry. These microscopes read by estimation only, and not by micrometric screws. This improvement would add to convenience and rapidity of reading and would relieve the eyes of the operator.

To increase the precision of distance readings reticules with as many as 15 horizontal lines are described. These are used in groups and in the highest order of work it is designed that no less than eight wires should be used. Confusion is lessened by the use of eye-pieces that allow only a few of the wires to be seen at one time. In general the usual three horizontal wires are all that are employed, with the important improvement in spacing due to the use of engraved lines. With Porro's extra lens the constant multiplier, usually 100, is capable of rectification by a shifting of this "centralizing glass," and it seems the author's intention to secure thus an absolute adjustment.

The work is notably deficient in its treatment of the reduction of vertical observations; neither the slide rule nor diagrams are mentioned for this purpose. No tables of any kind are given in the book, though titles of books of tables are mentioned on the last page. The diagrams in the book are injudiciously reduced without proper preparation; in consequence the lettering has frequently to be sought for with a magnifying glass.

Though the book abounds in useful information, this is not always germane to its subject, and often a deplorable amount of space is given to matters that might well have been omitted; several pages of the last chapter, for example, treat of the choice of routes for railroads as controlled by commercial and strategical considerations. The use of the leveling instrument is described, while barometrical formulas are not omitted. A number of pages are devoted to triangulation, the distribution of errors, the determination of the meridian, etc.

In view of the frequent appropriation of space for matters not properly coming within the field covered by his title, it is to be deplored that the author should give little or no information and should refer his readers to other treatises where his own explanations could have been included with great propriety. For example, the office work involved in the correction of co-ordinates obtained through traverse lines, is dismissed with two lines of explanation, and the reader is referred to another memoir, "on account of the author's very restricted space."

*Civil Engineer, 125 Lancaster St., Albany, N. Y.

JUST PUBLISHED

THE MANUFACTURE OF

CONCRETE BLOCKS

AND THEIR USE IN

BUILDING CONSTRUCTION

By H. H. Rice, Wm. M. Torrance, and Others

THE two most important applications of concrete in building construction at the present day are, first, reinforced concrete and second, concrete block construction. Concerning the first, a vast amount of literature is available; and the engineer desiring information finds technical periodicals and proceedings of engineering societies full of articles on reinforced concrete, while several excellent books are also available. Concerning the second, however, there has been an absolute dearth of literature, and at the same time there is a demand for information, which it is the object of the present book to supply. It is made up of a series of articles by different authors, being those submitted in competition for money prizes of $250 and $100 offered jointly by "Engineering News" and "Cement Age," of New York City. The two papers printed in full are those to whose authors the prizes were awarded; the abstracts that follow the second prize paper are those parts of the ten papers not awarded prizes that contained data not in the prize papers or that presented the same information in greater length or with more force. Altogether the papers and abstracts form a practical treatise on the manufacture of concrete blocks and their use in building construction that at present stands alone in the literature relating to cement and concrete.

Cloth, 6 x 9 inches, 130 pages, Illustrated. Price, $1.50, net

THE ENGINEERING NEWS PUBLISHING COMPANY
220 Broadway, New York

Machine Shop Practice.

Reviewed by Wm. W. Bird.*

20TH CENTURY MACHINE SHOP PRACTICE.—By L. Elliott Brookes, Author of the "Automobile Handbook," "Practical Gas and Oil Engine Handbook," and "The Calculation of Horsepower Made Easy." Chicago, Ill.: Frederick J. Drake & Co. Cloth; 5¼ x 8 ins.; pp. 631; 423 figures, mostly in the text, and 57 tables. $2.

The first part of this book is given up to arithmetic, geometry, mechanics, etc., and might properly be classed as a hand-book. The part devoted to machine tools is almost entirely descriptive and nearly all of it is but a reprint from numerous catalogues. What the author has to say on shop practice is more valuable and should be of interest to machinists. The author has tried to cover too much ground and the title of his book is altogether too ambitious. The book is well suited for young mechanics, but of little value to the manufacturer who wants to know what the twentieth century practice is to be.

THE RAILROAD MANUAL APPENDIX AND DIARY.—For the Use of Bankers, Investors, Trust Institutions and Railroad Officials. Supplementing Poor's Manual of Railroads. Sixth Annual Number, February, 1906. New York: Poor's Railroad Manual Co. London: Effingham Wilson. Flexible cloth; 6 x 9 ins.; pp. 284. $4.

A bond list, dates of annual meetings, stock registrars, transfer agencies, dividends paid from 1898 to 1905, railway statistics and a diary of annual meetings and dividend payments by months, days, etc., are given. Street as well as steam railways are included.

*Professor of Mechanical Engineering and Director of the Washburn Shops, Worcester Polytechnic Institute, Worcester, Mass.

THE VENTILATION, HEATING AND LIGHTING OF DWELLINGS.—By J. W. Thomas, F. I. C., F. C. S., Scientist in Ventilation and Heating, Author of "The Ventilation, Heating and Management of Churches and Public Buildings," "Coal, Mine-Gases and Ventilation," etc. London, New York and Bombay: Longmans, Green & Co. Cloth; 4¾ x 7¾ ins.; pp. 284; 72 illustrations in the text. $2.

So far as we remember, this is the only book on heating and ventilation yet published that is devoted particularly to dwellings. Much of the discussion is not applicable to American conditions, but on the whole the book contains a considerable amount of information which might be of direct benefit to engineers, architects and householders generally in almost any part of the world. In addition, much indirect benefit may be derived from the stimulus to thought afforded by the observations of the author on such natural phenomena as the movement of the wind, using that word broadly, and its relation to both ventilation and heating. Somewhat over half the space is devoted to the last two named subjects, and, considering the nationality of the author, fireplaces and allied subjects receive particular consideration. There is a chapter of nearly 25 pages on smoky chimneys, and a chapter of nearly equal length on heating greenhouses and stables. Appendixes deal briefly with "Some Electrical Conditions of the Air," present a few paragraphs and formulas on calculating the ventilating power of chimneys, give a table on the weight of 100 cu. ft. of air of different temperatures, etc., and another table the velocity and force of wind. In a final appendix the author takes up in some detail a subject already treated in the body of the book, namely, "The Position of Inlets and Outlets" for ventilating purposes.

THE ADJUSTMENTS OF THE ENGINEER'S TRANSIT AND LEVEL.—By Howard C. Ives, C. E., Assistant Professor of Civil Engineering, University of Pennsylvania. Second Edition. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Boards; 4¼ x 6¾ ins.; pp. 15; 11 figures in the text. 25 cts., net.

These handy notes have been revised, the figures have been placed in the text and a substantial binding has been adopted.

COMPRESSED AIR.—A Monthly Magazine Devoted to the Useful Applications of Compressed Air. Wm. L. Saunders, M. Am. Soc. C. E., Editor. Vol. XI., No. 3; May, 1906. New York: The Kobbé Co. (90 West Broadway). Paper; 7¼ x 10 ins.; pp. 4,025 to 4,059; illustrated. $1 per year.

This journal, for some time well-known in compressed air circles, has been enlarged to correspond with the growing field which it aims to cover. The number before us contains a variety of interesting articles, many of which are freely illustrated. The longer articles are reprints, but will be none the less valuable for those who do not see the originals.

DIRECTORY OF DIRECTORS IN THE CITY OF NEW YORK.—New York: The Audit Co. of New York. Cloth; 5¼ x 8 ins.; pp. 1,017. $5.

Some 24,000 names and addresses are given in this edition, together with the corporations which the various persons serve as directors or otherwise. The volume contains other useful information.

THE GROUND WATERS OF VERMONT FROM A CHEMICAL AND BACTERIOLOGICAL STANDPOINT.—By B. H. Stone, M. D., and C. P. Moat. (Reprinted from Annual Report of American Public Health Association.) Burlington, Vt.: The Authors. Paper; 6 x 9 ins.; pp. 8.

Unusual interest centers in this short paper, since it shows that of 1,733 samples of water from private wells and springs only 350 appeared to be normal as regards freedom from pollution, Moreover, the rural typhoid death rate in Vermont is higher than the urban and higher than the rural rate of any other New England State.

THE AUTOMOBILE OFFICIAL A. A. A. BLUE BOOK.—1906. A Touring Guide to the best and most popular routes in the Eastern and Northern States, with a Canadian Section. New York: The Class Journal Co. (Flatiron Building). Cloth; 5¼ x 9½ ins.; pp. 782; numerous maps. $3.

This is a handy road, hotel and garage guide for automobilists. It would be of almost equal value to any class of travellers providing their own means of locomotion, except that its bulk and weight would render it inconvenient for bicyclers and impracticable for pedestrians. The tours included radiate outward from 54 centers of as many sections or districts. A full index is provided. The numerous maps and the minute directions regarding forks, crossroads and the like are commendable, as is the book as a whole.

STANDARD REDUCTION FACTORS FOR GASES.—A Number of Tables Necessary for the Reduction of the Volume of Any Gas at Any Temperature, Pressure, and Degree of Saturation to Its Equivalent Volume Under Standard Conditions, Together with a Table for the Numerical Solution of Certain Exponential Equations. By Helon Brooks MacFarland, B. S., M. M. E., Associate Professor of Applied Mechanics, Department of Mechanical Engineering, Armour Institute of Technology, Chicago, Ill. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5¾ x 9¼ ins.; pp. 54. $1.50.

The use of these tables, of standard factors makes the reduction of observed volumes of gas or air to equivalent volumes under standard conditions, simply a case of multiplication. As there is no generally accepted standard conditions, four tables are given, viz.: (1) 62° F., 30 ins. mercury, (2) 32° F., 30 ins. mercury, (3) 0° C., 30 ins. mercury, (4) 0° C., 760 m. m., mercury, which are the results of the solution of the equation $\frac{p\,v}{T} = \frac{p_s\,v}{T_s}$, together with tables for the solution of exponential equations of the form $p\,v^n = p_1\,v_1^n$. Factors are given when n has the values γ, $\frac{1}{\gamma}$, $\gamma - 1$, and $\frac{\gamma - 1}{\gamma}$, in which $\gamma = 1.405$ is the ratio of the two specific heats of air, also the exponent $\frac{10}{9}$ for adiabatic expansion and the exponent $\frac{4}{3}$ for use when superheated steam expands from one volume to another. The solution of problems with the aid of these tables, therefore, eliminates the use of logarithms and reduces the number of operations to a minimum.

Publications Received.

CITY ROADS AND PAVEMENTS.—Suited to Cities of Moderate Size. By William Pierson Judson, M. Am. Soc. C. E., M. Inst. C. E., etc. Third Edition, Revised. New York: The Engineering News Publishing Co. London: Archibald Constable & Co., Ltd. Cloth; 5¾ x 8¾ ins.; pp. 197; illustrated. $2, net.

ELECTRIC RAILWAY TEST COMMISSION.—Report to the President of the Louisiana Purchase Exposition. Members of the Commission: J. G. White (Chairman), Geo. F. McCulloch, James H. McGraw, H. H. Vreeland, W. J. Wilgus. New York: McGraw Publishing Co. Cloth; 6 x 9½ ins.; pp. 621; 209 illustrations, mostly in the text, and 102 tables. $6, net.

ELECTRICAL ENGINEERING IN THEORY AND PRACTICE.—By G. D. Aspinwall Parr, M. Sc., M. I. E. E., A. M. I. Mech. E., Associate of the Central Technical College, City and Guilds of London, Head of the Electrical Engineering Department, The University, Leeds. London, Eng.: Macmillan & Co., Ltd. New York: The Macmillan Co. Cloth; 6 x 9 ins.; pp. 447; 282 figures in the text. 12s., net; American price, $3.25, net.

THE ELECTRICAL NATURE OF MATTER AND RADIOACTIVITY.—By Harry C. Jones, Professor of Physical Chemistry in the Johns Hopkins University. New York: D. Van Nostrand Co. Cloth; 5¼ x 8¼ ins.; pp. 212. $2.

INDUSTRIAL FURNACES AND METHODS OF CONTROL.—By Emilio Damour, Ingenieur Civil des Mines. Authorized Translation with Additions by A. L. J. Queneau, Consulting Engineer, The New Jersey Zinc Co. New York and London: The Engineering & Mining Journal. Cloth; 6 x 9½ ins.; pp. 317; 88 figures in the text, and 24 tables. $4.

MODERN ENGINEERING PRACTICE.—A Reference Library. Editor-in-Chief, Frank W. Gunsaulus, President Armour Institute of Technology, Assisted by Engineers and Technical Experts. Twelve Volumes. "Six thousand pages, four thousand illustrations, full page plates, and engravings." Chicago, Ill.: American School of Correspondence. Cloth; 6½ x 9¾ ins.
Vol I.: Electricity; Wiring; Telegraph.
Vol. II.: Generators; Motors; Storage Batteries, Automobiles.
Vol. III.: Electricity; Light; Power; Railways.
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Vol. X.: Machine Shop; Tool Making; Forging.
Vol. XI.: Mechanical Drawing; Perspective.
Vol. XII.: Ventilating; Heating; Plumbing; Carpentry; Index.

THE PRACTICAL TESTING OF DYNAMOS AND MOTORS.—By Charles F. Smith, Assoc. M. Inst. C. E., A. M. I. E. E. Second and enlarged edition. Manchester, Eng.: The Scientific Publishing Co. Cloth; 5½ x 8¼ ins.; pp. 306; 108 figures in the text. 6s., net; American price, $2.

THE PRINCIPLES OF ELECTRIC WAVE TELEGRAPHY.—By J. A. Fleming, M. Inst. E. E., etc., Professor of Electrical Engineering in University College of the University of London. London, New York and Bombay: Longmans, Green & Co. Cloth; [illegible] ins.; pp. 671; folding and other plates and [illegible] illustrations. $6.60, net.

STEAM TURBINE ENGINEERING.—By T. Stevenson, A. M. Inst. C. E., A. M. I. E. E., and H. M. Hobart, M. I. E. E., Mem. A. I. E. E. New York: The Macmillan Co. London: Whittaker & Co. Cloth; 6 [illegible] pp. 814; 516 figures, mostly in the text, and [illegible] $6.50.

TEXT-BOOK OF MECHANICS.—By Louis A. [illegible] Jr., Assistant Professor of Mathematics and [illegible] in Stevens Institute of Technology. Vol. I. New York: John Wiley & Sons. London: [illegible] & Hall, Ltd. Cloth; 5 x 7½ ins.; pp. 142; [illegible] in the text. $1.25, net.

TURBINES.—By W. H. Stuart Garnett, of the Inner Temple, Barrister-at-Law. London, Eng.: George Bell & Sons. New York: The Macmillan Co. Cloth; 5½ x 8¾ ins.; pp. 283; 83 figures, mostly in the text. $2.75.

UBER WASSERKRAFT- UND WASSERVERSORGUNGS-ANLAGEN.—A Practical Guide to Their Planning, Calculation and Construction. By Ferdinand Schlotthauer. Munich and Berlin, Germany: R. Oldenbourg. Cloth; 5½ x 8½ ins.; pp. 225; 39 figures in the text, and many tables. 7 marks; American price, $2.00.

WATER AND LIGHTING DEPARTMENT OF THE CITY OF HARRISBURG, PA.—Annual Report of the Board of Commissioners for the Year 1905. (Board of Commissioners: John A. Affleck, President; George J. Hutton, Edmund Mather.) Paper; 5¾ x 9 ins.; pp. 45.

SANITARY LEGISLATION IN THE UNITED STATES ENACTED DURING THE YEAR 1905.—Special Bulletin of the State Board of Health, State of Rhode Island and Providence Plantations. Compiled for the State Board of Health by Charles V. Chapin, M. D. Providence, R. I.: Pub. Doc. Cloth; 5¼ x 9¼ ins.; pp. 318.

BRITISH COLUMBIA MINES.—Annual Report of the Minister of Mines for 1905. (William Fleet Robertson, Provincial Mineralogist.) Victoria, B. C.: Pub. Doc. Paper; 7¼ x 10¼ ins.; pp. 275; folding and other plates, text figures and large folding map.

THE PROGRESS AND INFLUENCE OF TECHNICAL EDUCATION.—By Victor C. Alderson, President Colorado School of Mines. (Reprinted from the Proceedings of the Society for the Promotion of Engineering Education, Vol. XIII., 1905.) Paper; 6 x 9¼; pp. 127 to 145.

IOWA ENGINEERING SOCIETY.—Proceedings of the 1906 Meeting. Iowa City, Iowa: The Society (C. L. Bryden, Secy.). Paper; 6¼ x 9¼ ins.; pp. 180; plates and text illustrations. 50 cts.

STATISTICS, CITY OF CHICAGO.—Quarterly. Annual, 1905. Vol. V., No. 4. Chicago, Ill.: Bureau of Statistics and Municipal Library. Paper; 9¼ x 11½ ins.; pp. 40 + xiii.

RECEIPTS AND EXPENDITURES OF ORDINARY REVENUE, 1900-1904.—Special Publications No. 12. Statistics Department, City of Boston. Boston, Mass.: Pub. Doc. Paper; 9½ x 11¾ ins.; pp. 63; one folding sheet.

THE POLLUTION OF OYSTERS.—By George A. Soper, Ph. D., Member New York Bay Pollution Commission. (Reprinted from Annual Report of American Public Health Association.) New York: The Author (29 Broadway, New York). Paper; 6 x 9 ins.; pp. 7.

COMMISSIONER OF DAMS AND RESERVOIRS.—State of Rhode Island and Providence Plantations. Annual Report made to His Excellency George H. Utter, Governor, January, 1906. (Walter C. Simmons, Commissioner.) Providence, R. I.: Pub. Doc. Paper; 5¾ x 9 ins.; pp. 34; folding and other plates, and six tables.

WATER-SUPPLY AND IRRIGATION PAPERS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ x 9 ins.
Nos. 165, 166, 168, 169 and 171: Report of Progress of Stream Measurements for the Calendar Year 1905. Prepared under the direction of F. H. Newell.
Part I. (166): Atlantic Coast of New England Drainage. By H. K. Barrows and John C. Hoyt. Pp. 155; one plate and two text figures.
Part II. (168): Hudson, Passaic, Raritan and Delaware River Drainages. By R. E. Horton, N. C. Grover and John C. Hoyt. Pp. 101; one plate and two text figures.
Part IV. (168): Santee, Savannah, Ogeechee and Altamaha Rivers and Eastern Gulf of Mexico Drainages. By M. R. Hall and John C. Hoyt. Pp. 164; one plate and two text figures.
Part V. (169): Ohio and Lower Eastern Mississippi River Drainages. By M. R. Hall, F. W. Hanna and J. C. Hoyt. Pp. 153; one plate and two text figures.
Part VII. (171): Hudson Bay and Upper Eastern and Western Mississippi River Drainages. By F. W. Hanna and John C. Hoyt. Pp. 113; one plate and two text figures.

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